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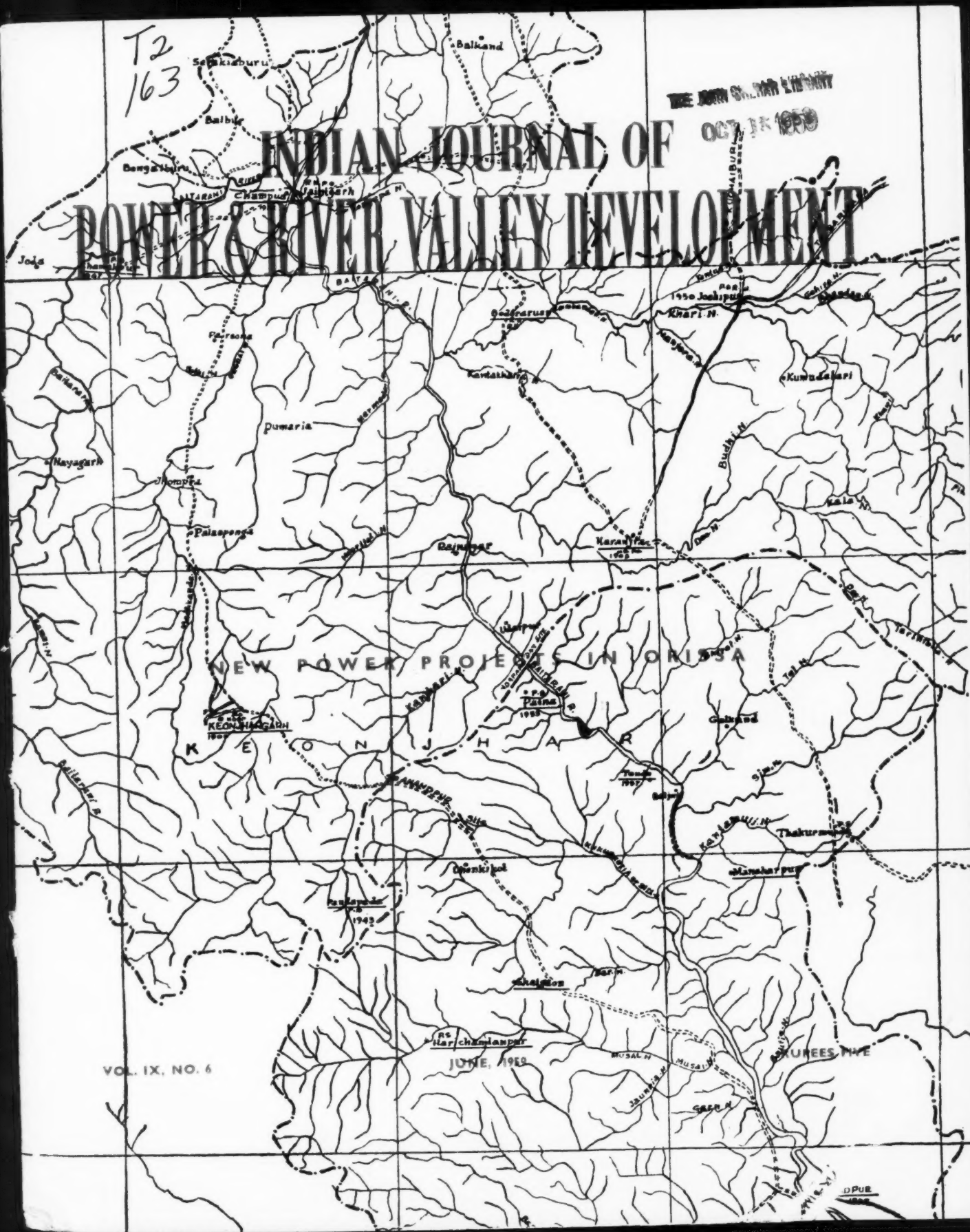
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Kala N.
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Jhompra
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Karanjia
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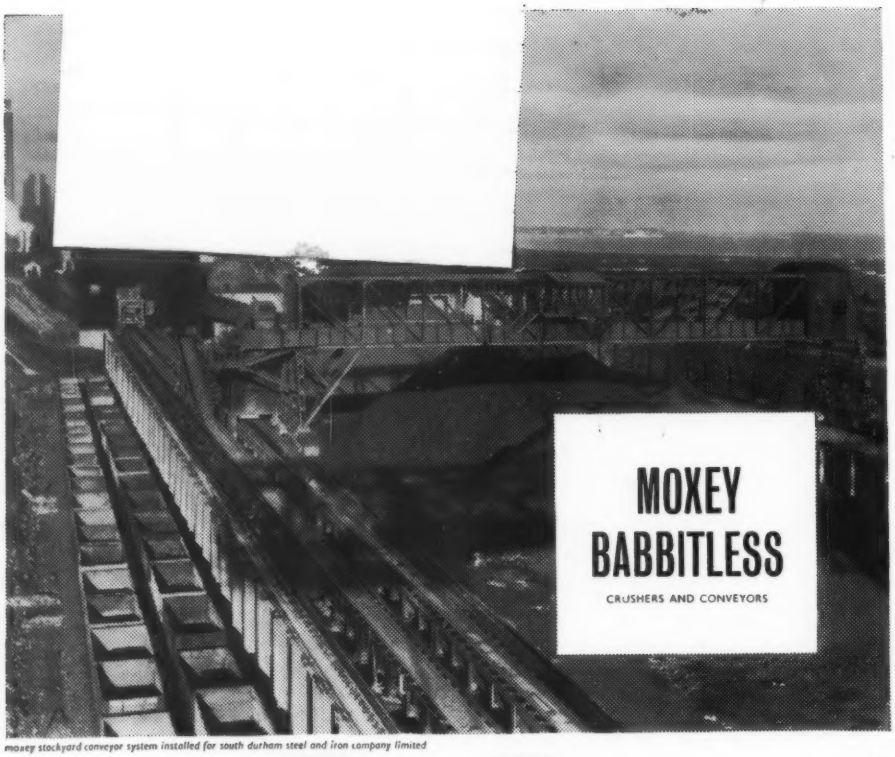

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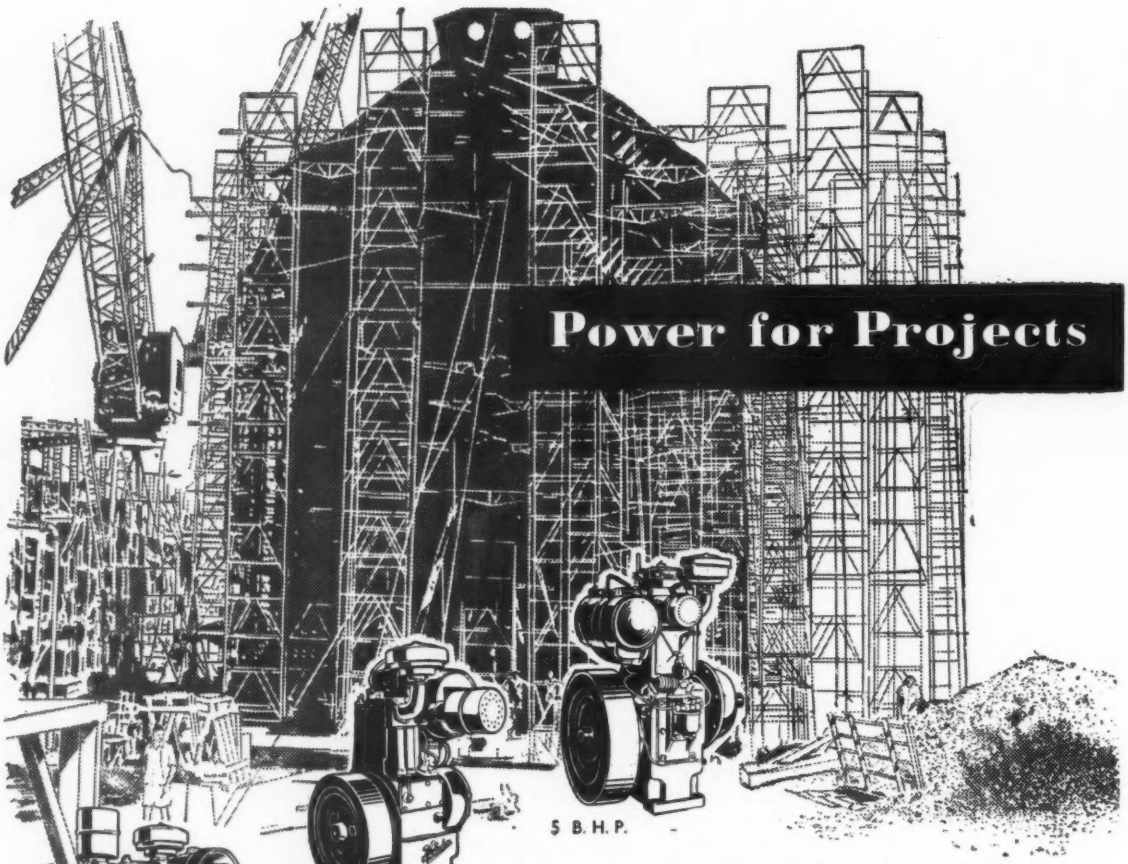

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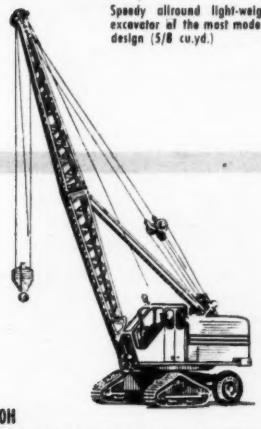

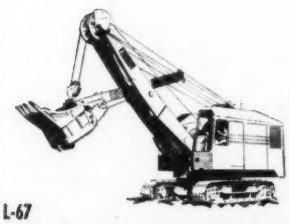

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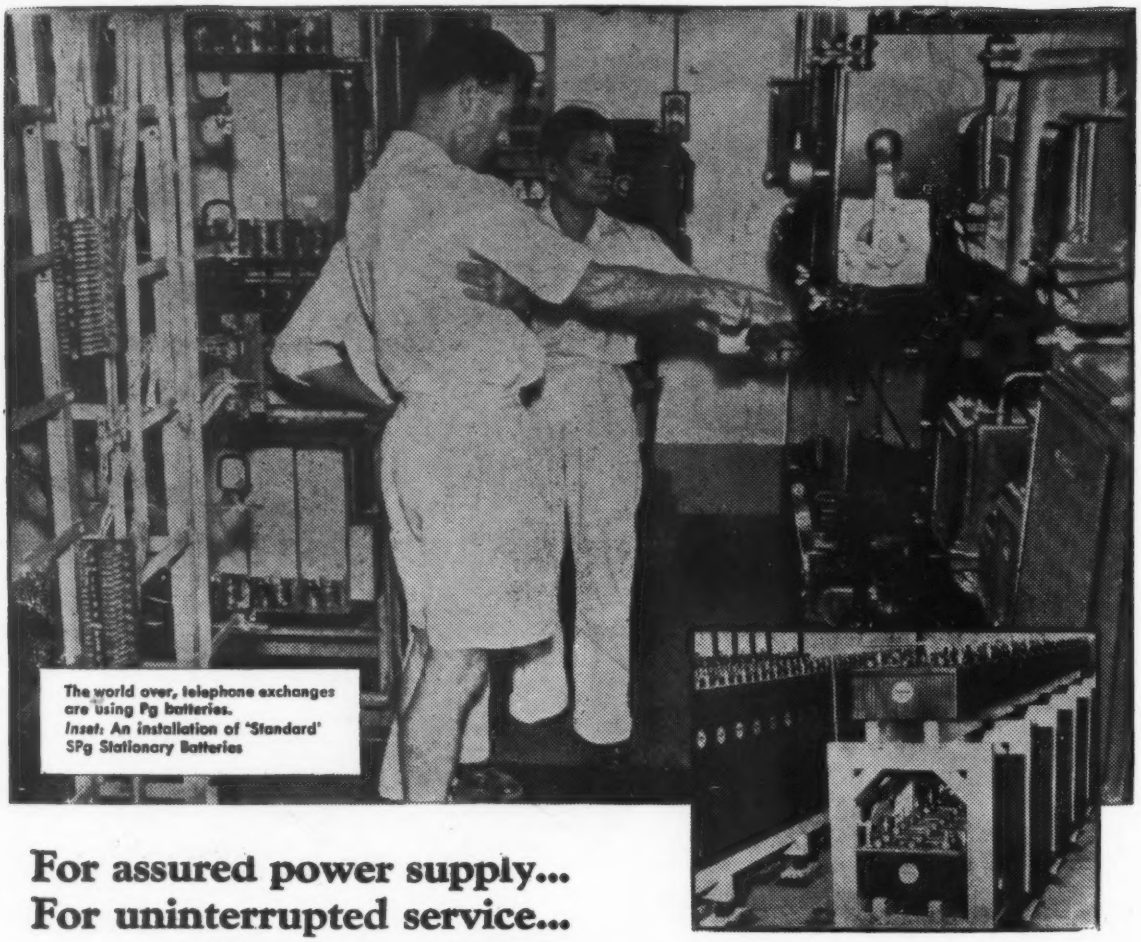

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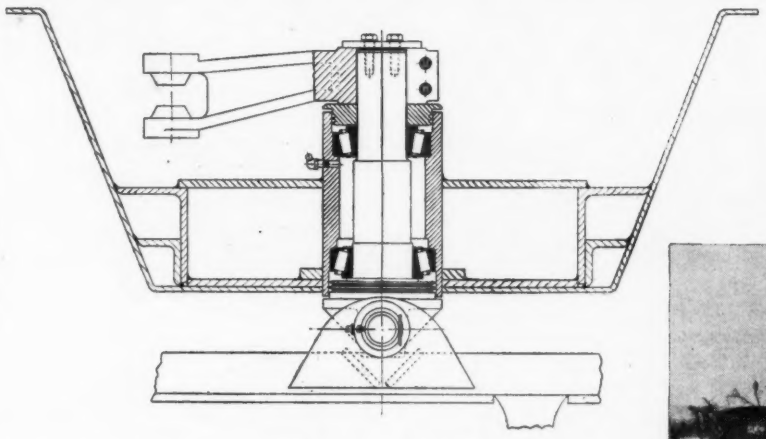

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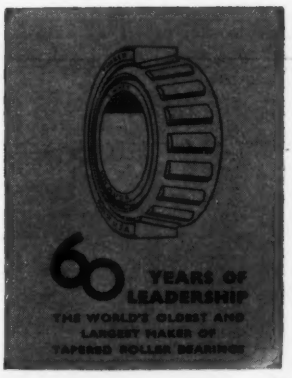

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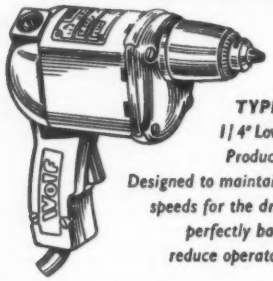

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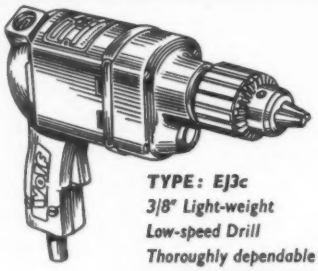

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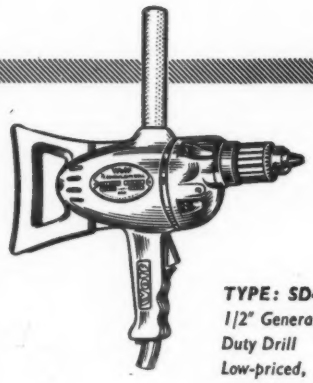

TYPE: SD4c
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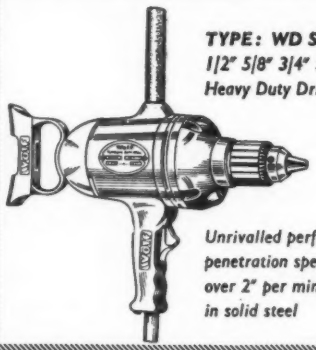

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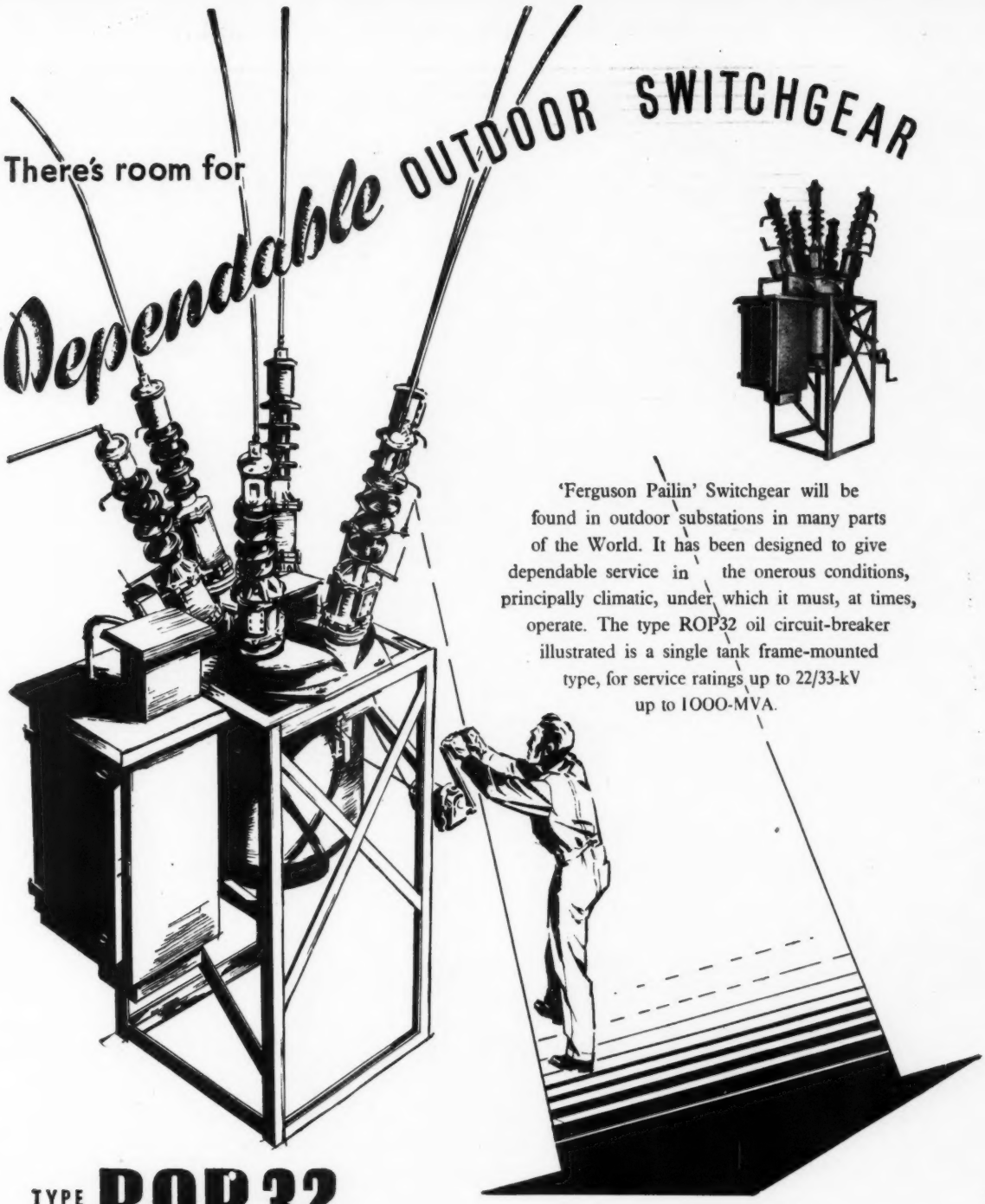

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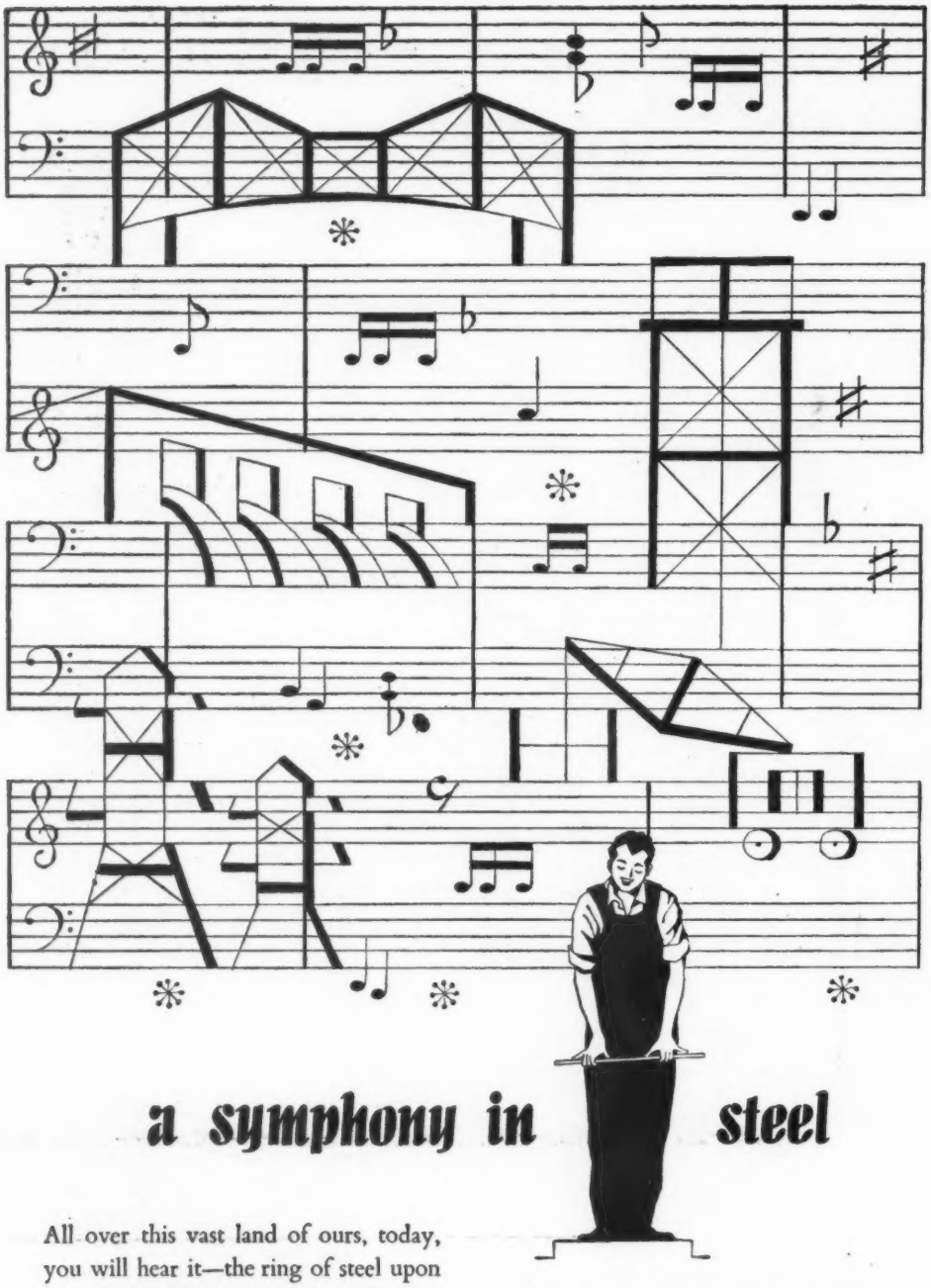

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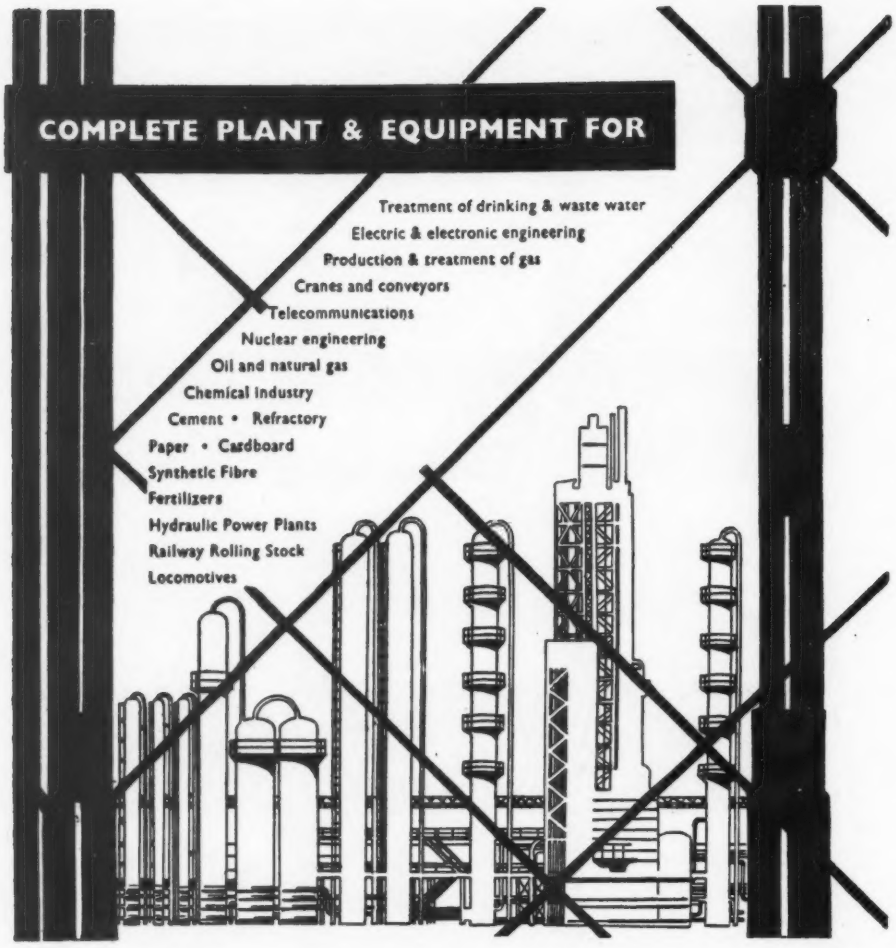

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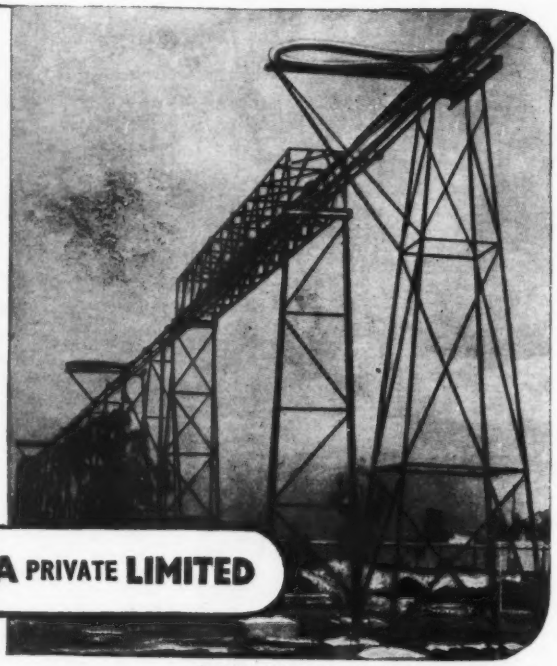

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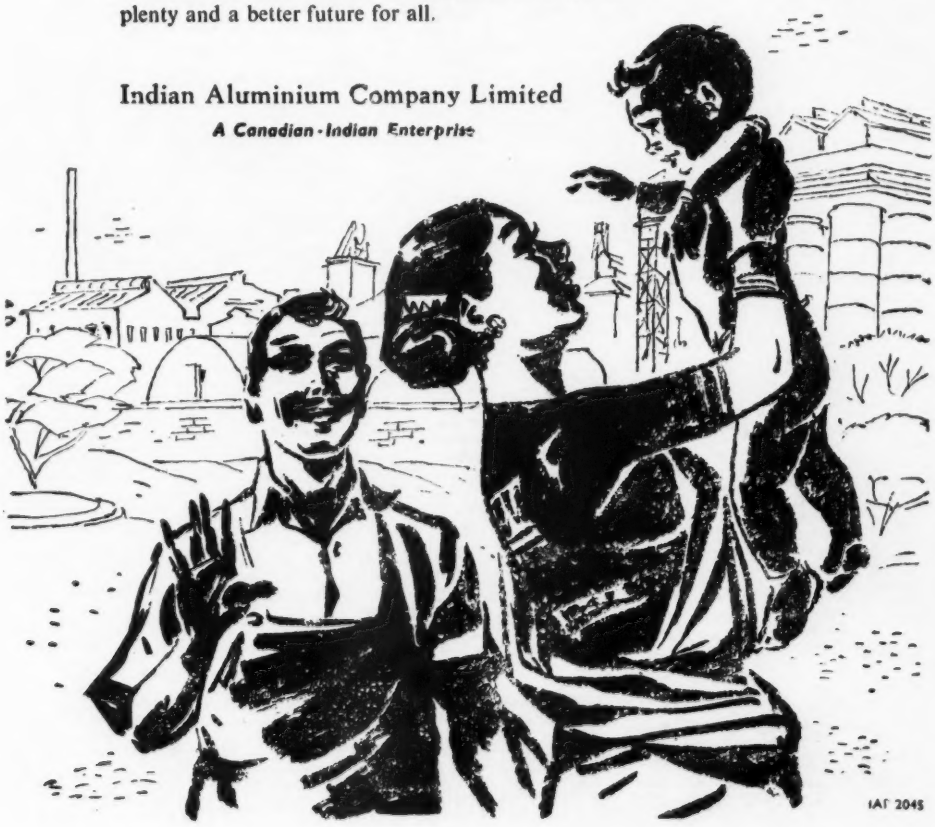

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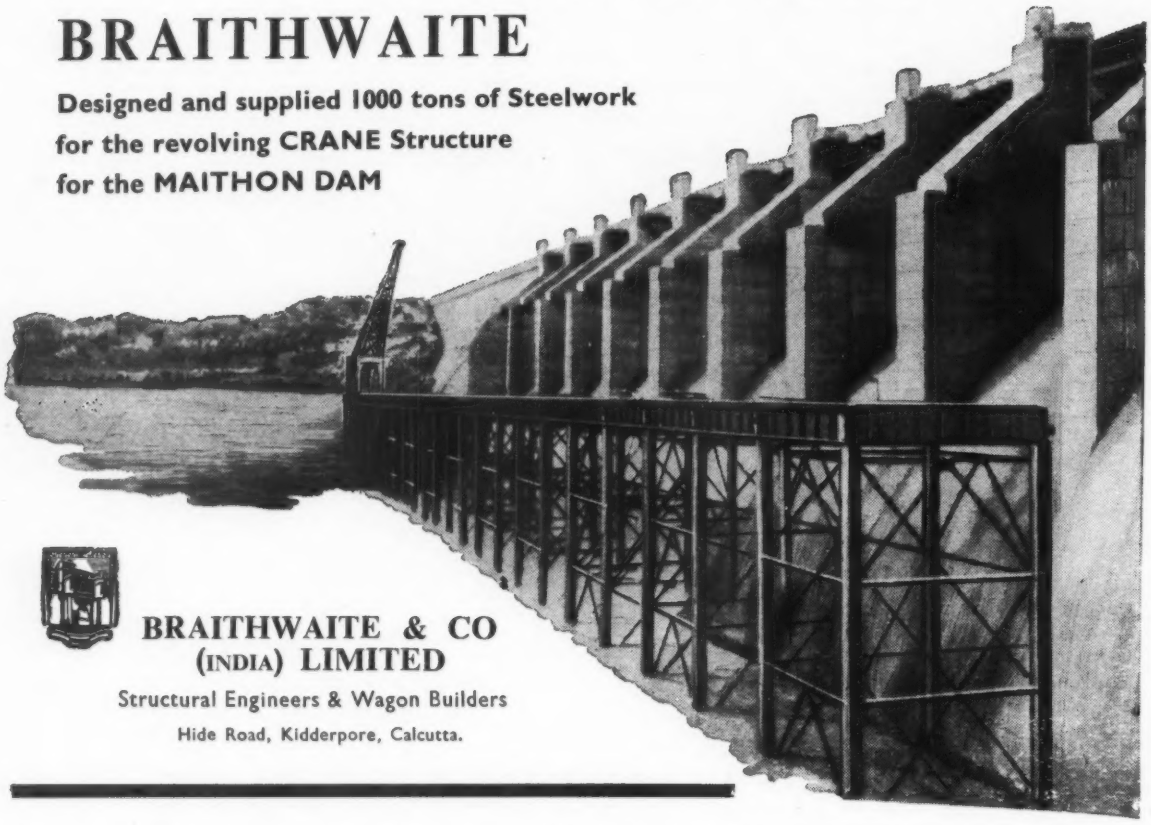

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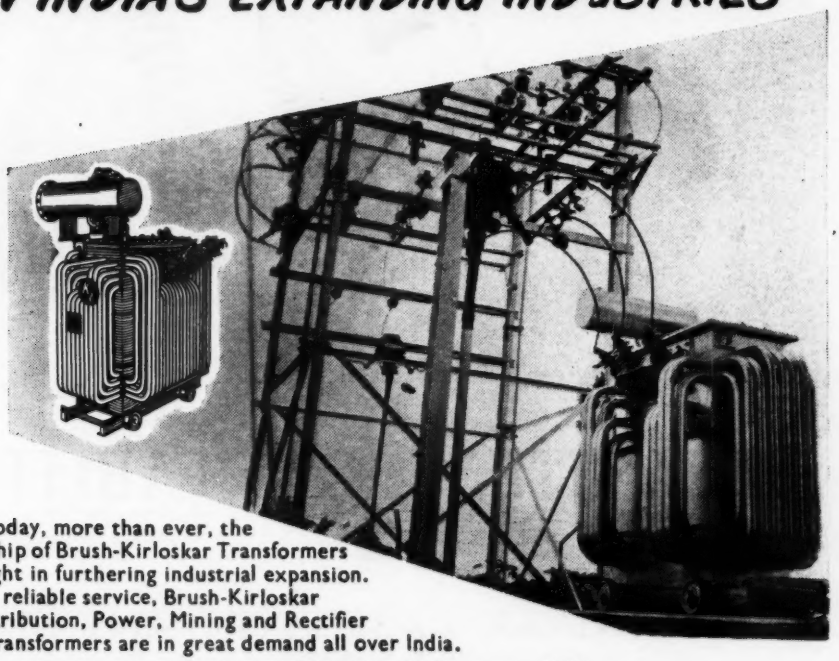

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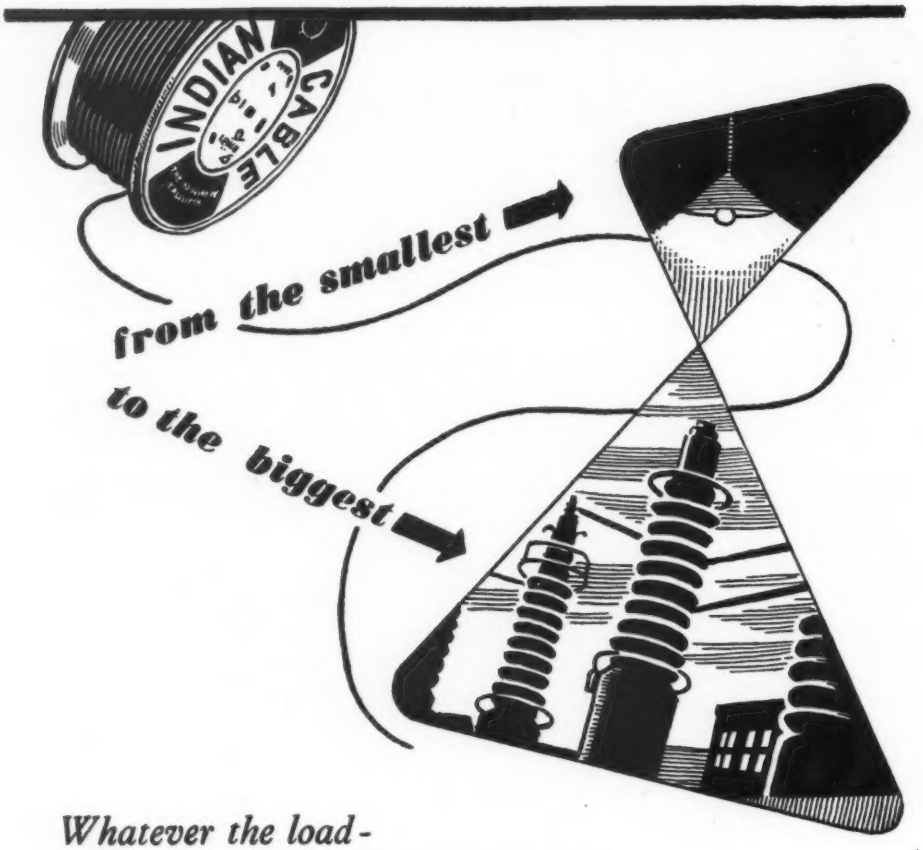

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VOL. IX — **JUNE, 1959** — **NO. 6.**

NEW POWER PROJECTS IN ORISSA

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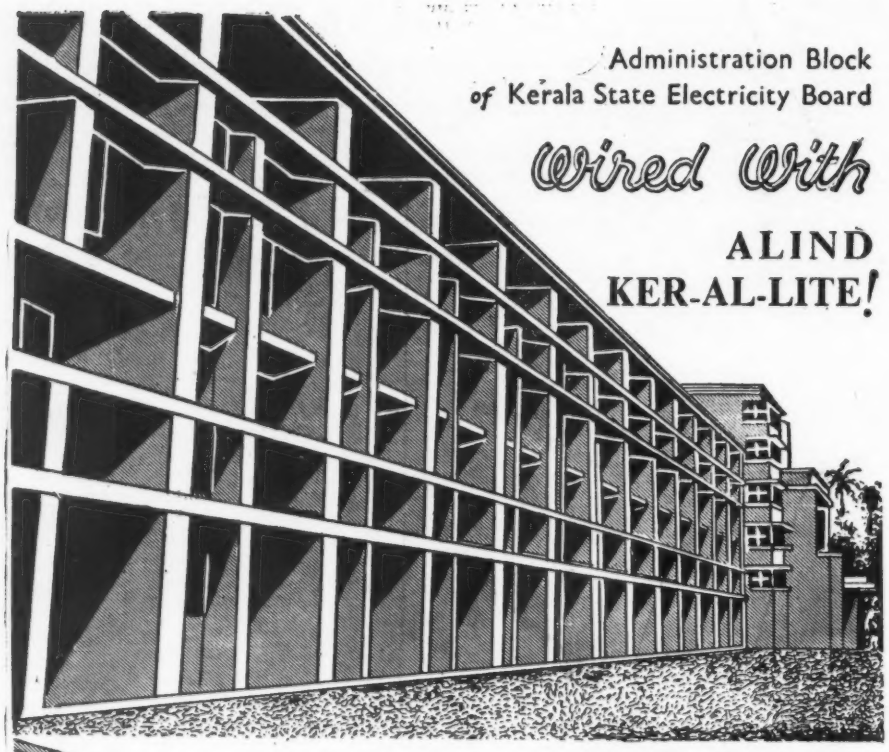

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Messages

I am glad to know that a Special Number of the 'Indian Journal of Power and River Valley Development' is being published shortly, devoted to the new Power Projects in Orissa.

The neglect which this part of India suffered from during the past centuries created a sense of frustration from which the people had to be recovered and new hope created. The Hirakud Dam Project ushers in that age of hope for the people of Orissa. Following upon this the Machkund Project has been completed. The Bhimkund Project and the Balimela Project are also under examination. Besides these the Brahmani and the Subarnarekha Projects have to be undertaken in course of time. These projects which have been completed are so many jewels in the crown of success which the National Government have achieved so soon after independence. India's prosperity depends upon these projects. Details regarding the irrigation and power potential of some of these projects can be gathered from the articles written by the respective engineers in this Special Number.

I am sure the Journal will give a clear picture of what has been achieved and what is going to be achieved.

Hare Krushna Mahtab
Chief Minister
Government of Orissa

Messages

Planning is a difficult task. We have to plan to meet our future requirements, and also the execution has to be planned. In a State like Orissa with her immense natural resources of minerals and maritime facilities, industries of various types are sure to make vast strides in the near future, and the chances are that one can never err in over-estimating the demand. Today there is a great power shortage. I am confident that during the Third Five-Year Programme, Orissa shall see tremendous expansion in power production. It would be interesting to find that the scope for evolving the appropriate type or types of Power production is immense. We have got facilities for Hydro-electric generation on perennial rivers and also on rivers with seasonal flow where big Reservoirs become inevitable. We have got immense possibilities for installation of low-head generation on the Canal systems and the Weir Head on rivers with a regulated flow. Besides these, we have got coal, and the low-grade coal and coal dust could be utilised for thermal generation, and such Stations come handy to boost up the grid between the principal river systems. The advantages and disadvantages of each type of installation, taking into consideration the technical and financial aspects involved, make it a most interesting study in the achievement of optimum of economy and efficiency in Power generation for the present and for the future. The time-factor in putting up these installations is very important. I am confident that in the Third Five-Year Programme the Power development will incorporate features that will be of interest to the world experts. The total resources of Power generation apart from Thermal installations is more than thirty lakhs kilowatts, and we are planning to produce about ten lakhs kilowatts of electrical energy. The future development of industry in this State is indeed very bright.

I congratulate the Editor on his keen interest in the Power Development Projects in Orissa.

S. N. BHANJA DEO
Raja Kanika
Minister, Government of Orissa

I congratulate the learned editor and the publishers of the Indian Journal of Power and River Valley Development for the publication of a special number of the Journal fully devoted to the new power projects that have been undertaken in Orissa. Orissa is full of potential resources for development of hydro-electric power in addition to the varied type of mineral and forest resources. Orissa could be described to be the epitome of natural wealth of India though it has so far been the epitome of India's poverty in the words of Mahatma Gandhi. The natural resources of this potentially rich tract will be developed only if power and irrigation facilities could be expanded. I am sure, the special issue of this valuable Journal will add to the knowledge and information of the public, industrialists and the technicians so that our future development plans could be framed and executed in a more realistic and useful manner.

RADHANATH RATH
Minister, Government of Orissa

INTRODUCTION

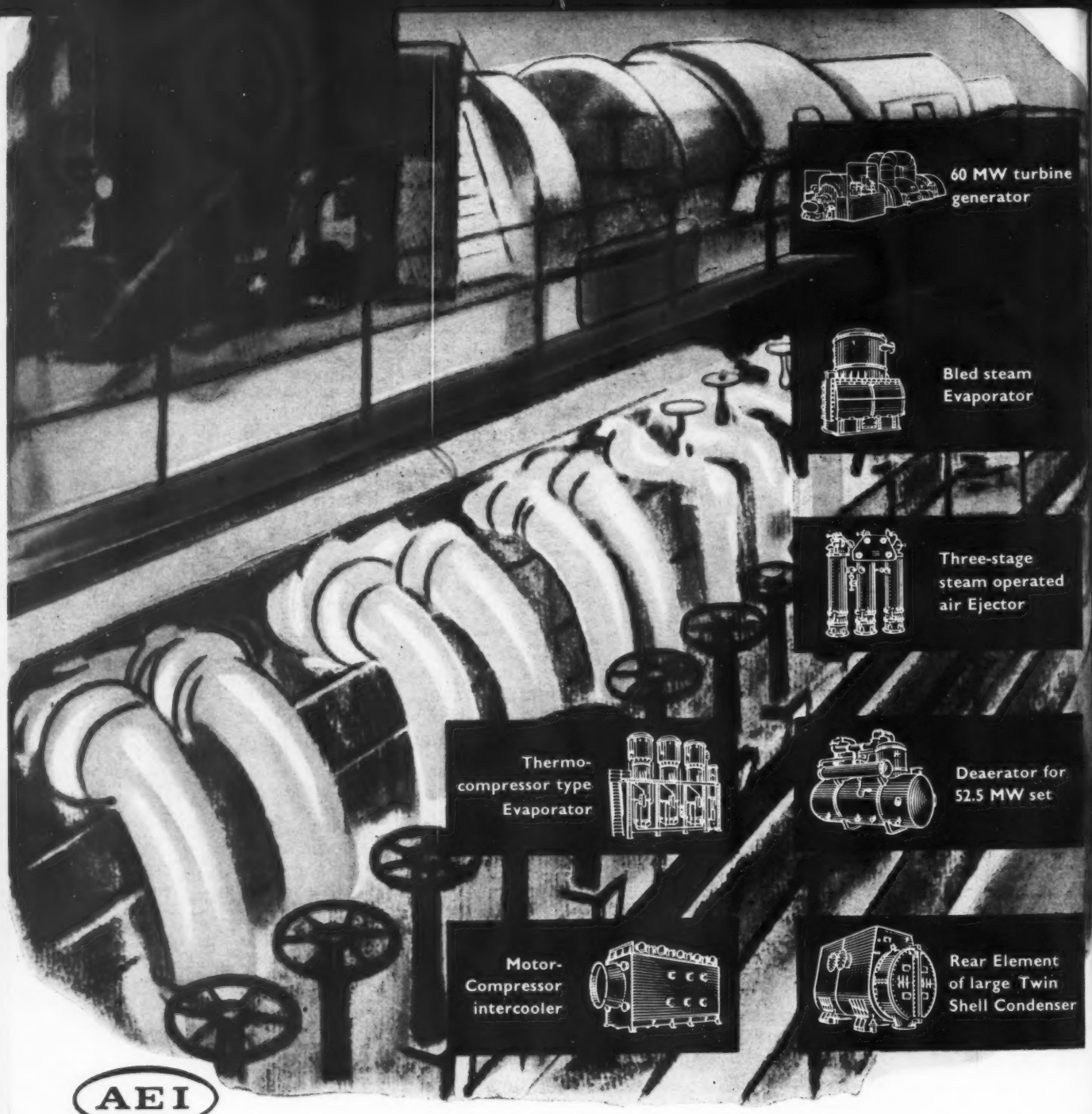
Orissa has always been considered a backward State from the point of view of development. But only since the attainment of independence the natural resources of the State could be assessed in a larger perspective and with greater accuracy, and it now appears that if there is a steady and yet rapid pace of development, this State would soon become a very significant factor in the country's economy.

Large rivers flow through this State; it is rich in many minerals; it has numerous people who are hardy and are endowed with a rich traditional culture. Thus all the elements necessary for growth are present; it is now a question of bold and imaginative leadership which will rouse the people to constructive hard work, educating them as they proceed, and not fritter their energies in wasteful and unproductive controversies.

Hirakud and Rourkela now symbolise the new spirit of Orissa. With power to control mighty floods and to generate electricity and irrigating waters to fertilise industries and lands, and with the ability to convert the ores from the bowels of the earth into steel which is the base of all industrial devolopment, the people of Orissa, given modern technical education, can again rise to new heights of endeavour and accomplishment—heights which even now stand as monuments in the field of sculpture and architecture throughout the land.

Already the rich mineral potentialities of Orissa, coupled with prospects of water transport and port facilities at Paradip, are attracting entrepreneurs from far and near. There was a time when Hirakud power, it was considered, would remain surplus for years to come. Now both Hirakud and Machkund and all existing generating capacities are too small to meet the demand. New hydro generation, on large enough scale, has to be envisaged right now. But as their completion will take time, immeditate heavy demands have to be met by urgent execution of thermal generating stations of large capacities.

Fortunately the State is today in possession of bold and imaginative engineering leadership. This has considerably helped Orissa to draw up big plans that can look far ahead and yet not lose the grip on details for the immediate. In this issue are collected some of the major projects for electricity development in the State in the near future that will provide a perspective to all who are interested. We are sure that its reading will richly benefit not only those who belong to the State but also those who are today engaged in planning for power elsewhere.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Development of Power Resources in Orissa during the Third Plan

By P. V. A. NARAYANAMURTHY
and J. M. PATNAIK

AS in other parts of India, demand for power in Orissa State has outstripped the generating capacity existing and under construction. Immediate demands for power cannot possibly be met by developing any large hydro-electric schemes the scope for which is very large indeed in this State due primarily to the well known fact that development of hydro-electric projects involving large civil works take many years to be completed. Most of the schemes that have been studied or investigated are such as would take six to eight or even more years to be completed and these cannot, therefore, cater to the large and pressing demands for power. Naturally, the only way that the power demand can be met is to build thermal stations of reasonably large capacities as these can be constructed and commissioned in much lesser time, say, about 3 years. Further, the State is also very rich in coal deposits and very large thermal stations can be built early at the pit heads to utilise low cost coal and the power transmitted to load centres. This advantage has necessarily to be utilised to cater to the pressing load demands in the State and the emphasis in the Third Plan period has to be as much on the utilization of coal available in abundance in the State and building up reasonably big thermal stations as much as on development of some of the available hydro resources.

As the power development in the State has been in two distinct areas viz., areas fed by the Machkund power system and Hirakud system, the power development in these two areas are reviewed herein separately with a view to determine the additional generating facilities required in these two areas to meet the power deficit. Of course, the possibilities of interlinking the two systems ultimately has also been kept in view so as to meet economically the power deficit in one area by the surplus power that may be available in the other area.

HIRAKUD SYSTEM

With a view to meet the committed loads including the large power demand of the Rourkela Steel Plant which, when the fertiliser factory is completed may be of the order of 110 mW, the second stage development of aluminium factory and Railway Electrification Project, it has been necessary to utilize not only the generating capacity of the 75 mW thermal station of the steel plant by operating the Hirakud system in parallel and integrated with this power plant, but also the 6 or 7 mW of generating capacity of the existing small thermal stations at Rajgangpur and Chowdwar at present kept idle. In addition a sixth generating set of 37.5 mW will also be installed at Hirakud as only thereby the total anticipated maximum demand of 281 mW before the end of the second, Plan Period can be met under all operating and reservoir conditions keeping one 37.5 mW set as common standby. In fact, certain demands from important industries like ferro-chrome factory at Jajpur Road and others in Cuttack-Puri area cannot still be met in full without additional generating capacity even during this period. To meet the power shortage arising from the above and other similar demands bound to come up and also unexpected variations in generation at Hirakud due to variation in the water discharged by the Mahanadi, a scheme has been formulated for establishing a 60 mW station near the Rampur Collieries.

Though the need for such a thermal station has been recognised on all sides, it could not be taken up during the Second Plan period for want of foreign exchange. Though it may not be possible to forecast the power demands in the subsequent Plan periods with great accuracy, yet from the experience and trend of power development of the past years and taking into consideration the possible power demand in the northern and north-western districts of the State, which have immense potentialities for industrialization, the power demand can safely be assumed to grow at the same rate as in recent years. On this basis, it will be necessary to plan and execute power schemes for providing an additional generating capacity of 190 mW in the Hirakud area before the end of the Third Plan period. We naturally think of utilizing one or more of the large hydro-electric schemes capable of being developed in the State to meet the power deficit but completion and commissioning of any major hydro-electric project would take 6 to 9 years. Thus it will be evident, that we will have to seek some other power source for meeting the power deficit in the third Plan period. As already indicated, the logical choice appears to be to construct one or more

The ideas and views regarding the future power development in the State are exclusively those of the authors and the State Government are in no way committed to implement them.

thermal stations, with sufficient firm generating capacity to meet the total deficit of 190 mW. Assuming a 60 mW thermal station will be constructed at Rampur where the coal available will not permit a large station, another station of about 180 mW including a standby set of 60 mW will be necessary. These two thermal stations will together just meet the power deficit in the Hirakud area. Maybe further investigations may indicate the desirability of having only one large station at Talcher where abundant deposits of low grade coal ideal for use in-power stations are available instead of two stations, one near Rampur Collieries and another at Talcher. Maybe, ultimately, a thermal station at Talcher will have four 60 mW sets, giving a firm capacity of 180 mW against a power deficit of 190 mW.

It is also planned that one or more of the larger hydro-projects such as Bhimkund and Mahanadi third stage development should be simultaneously taken up for execution at the end of the second Five Year Plan for the beginning of third Five Year Plan period, such that they will be completed and at least partly commissioned in the beginning of the fourth Five Year Plan period in time to meet the power deficit in that period without again taking recourse to augmenting the thermal station generating capacity.

The thermal stations built up in the third Five Year Plan will ultimately serve to meet the seasonable variations in the water discharged by unexpected additional demands for irrigation from the irrigation-cum-power projects like Hirakud and Bhimkund. The installed thermal capacity will be roughly about 25% of all the hydro capacity available at the end of the fourth Plan period in the State. The two existing small thermal stations at Rajgangpur and Chowdwar will no longer serve any useful purpose in the Hirakud area and may have to be shifted to the other under-developed areas of the State to develop the industrial and other loads in those areas.

BHIMKUND PROJECT

This is a multipurpose project on the river Baitarani in north Orissa. Detailed investigation of this project has shown that, in the first stage of development 300,000 kW of firm power and 8 million kWhrs. of secondary power will be available. The installed capacity will be 3,86,000 kW which will ultimately be increased to 4,78,000 kW in the second stage, when the increase in firm power is estimated to be another 80,000 kW. The first stage of development is projected to be completed in 9 years' time. It is expected that the construction of the project will start from 1961-62 (i.e. the first year of the third Five Year Plan). The Bhimkund Power House will be connected to the Hirakud System by double circuit 132 kV transmission lines to Joda, Talcher and Khargpur linking up Bhimkund with the D.V.C. system. It has been considered desirable that preliminary work on the project and the initial civil engineering works not involving foreign exchange should be taken up for execution even during the end of the second Plan period so that power can be generated at least in the beginning of the fourth Plan period.

180 MW THERMAL STATION AT TALCHER

Extensive low grade coal deposits estimated at 1150 million tons are reported to exist in the Talcher area and such coal can be economically utilised only for power generation. The Brahmani river which runs close to Talcher can supply the necessary water for a large thermal station. Hence Talcher appears to be the best place for locating a 180 mW thermal station. The above considerations also indicate the desirability of having one 240 mW thermal station at Talcher rather than one of 180 mW at Talcher and another of 60 mW at or near Rampur. A 132 kV line interlinking Chainpal (close to Talcher), where already exists a 132 kV substation of the Hirakud Project and Rourkella in the industrial belt via Barakote appears necessary to utilize all the power that will be available at Talcher and Bhimkund. Other points in favour of locating the 180 mW thermal station at Talcher are (1) the National Coal Development Corporation have plans to introduce modern mechanisation in the Talcher coal fields which will make available coal at low cost for power generation. (2) The ferro-chrome factory at Jajpur Road or Talcher and other industrial loads in this area can be directly served by this thermal station instead of by Hirakud Power House.

60 MW THERMAL STATION AT RAMPUR

The 60 mW thermal station now projected is proposed to be located near Rampur Collieries on the Ib river about 6 to 8 miles from Jharsuguda. It has to be executed and commissioned at least by 1964-65 in order that the power deficit can be met. In view of the meagre deposits of coal and also as the coal is of superior variety which could be used by locomotive and industries this may not be an ideal place for locating a thermal station. The capacity of any station if established here, will necessarily be limited to 60 mW which is a disadvantage. It is in view of these considerations Talcher would appear to be the best place for locating the thermal station.

GENERATION AT LOW HEADS

The question of utilising the large quantities of water discharged by various canals at comparatively small heads, of 5 to 10 ft. in the Mahanadi Delta and elsewhere to generate power is under investigation. It is expected that sizable amounts of power of the order of 4 or 5 mW can be generated from this source by using special submersible turbo-generators developed recently in France.

MAHANADI VALLEY DEVELOPMENT (STAGE III) AT DULESWAR

There is a proposal for power development by utilising the tail water from the power station at Chiplima under the Hirakud Project stage II, in two further stages. The stage third of the scheme will mainly consist of constructing a weir across the Mahanadi above Binka to pick up the regulated water discharged from the Chiplima power house or take the Chiplima tail-race along the right bank for some distance, cross the Mahanadi at a suitable point by a syphon and then take it in contour on the left side of Mahanadi upto Duleswar, a little above Boudhraj town on the opposite bank where the drop will be utilised to generate power. A power house at Duleswar (Bolangir District) will have a maximum head of 140 ft. This scheme will also provide irrigation to over 60,000 acres. The installed capacity of this power house would be of the order of 2,000 mW. This scheme has already been taken up on hand for detailed investigation by the Special Investigation Branch created for investigating the various Hydro-Electric Projects in the State.

MAHANADI VALLEY DEVELOPMENT (STAGE IV) AT TIKKERPARA

In this stage of Development, it is proposed to take the tail-race water from Duleswar Power House along the left bank of Mahanadi by means of a power channel and drop in at Tikkerpara (Dhenkanal District) utilising a head of 90 ft. The installed capacity at this power house would be about 124 mW.

RANGALI PROJECT

This is a multipurpose project on the river Brahmani and the dam is proposed to be located at Rangali. The power potential of this project is of the order of 63 mW at 60% load factor. The power station under this project can be connected to the Bhimkund grid at Barakote and Hirakud Grid at Chinpal. This project is under investigation and the results of investigation are expected to be available in about a year.

MACHKUND SYSTEM

The demand for power in the area fed from the Machkund system may be of the order of 26.0 mW by 1960-61 against 27.5 mW available as our share from the joint scheme. Though there will be a surplus of 1.5 mW by the end of the second Five Year Plan period a deficit of about 24.5 mW is expected by 1965-66 if the normal anticipated growth of power demand is to be met. To meet this power deficit it is proposed to take up the Balimela Hydroelectric Project during the third Five Year Plan period. This will cater to the various industries in Koraput, Kalahandi, Ganjam and Puri districts. Another point in favour of early execution of this project is that it is situated in the heart of Dandakaranya area. Availability of abundant power from this scheme will help to promote rapid industrial and agricultural development of the Dandakaranya area which abounds in mineral and forest wealth. The necessary thermal station support which is essential for hydro-projects in general in our country to meet the variation in river flow will be afforded by interlinking the hydro-systems of the Machkund area with those of Hirakud area to form an extensive electrical grid covering practically the whole State. The large thermal stations proposed to be built in the Hirakud area will then serve to firm up the hydro generation in the Machkund area also.

BALIMELA PROJECT

This is a multipurpose irrigation-cum-power project. The scheme provides for the construction of a dam across the Machkund river about 3 miles from Balimela where a drop of about 1000 ft. will be available for power generation. Irrigation facilities can also be provided for about 2.4 lakh acres of land in the Malkangiri area by gravity and lift canals. The total discharge that will be available from the proposed reservoir is 2650 cusecs. The Jalaput Dam of the Machkund Project will give a regulated flow of another 1400 cusecs. It is also the intention to divert alternatively the water from the Kolab river to Machkund and Balimela and utilise a regulated flow of 1250 cusecs for power generation. All this water if utilised at Balimela will enable a generation of 6,00,000 kW at 60% L.F. and another 1,20,000 kW at 60% L.F. at Machkund. Thus in all the overall potential of Balimela Power Scheme is 7,20,000 kW at 60% L.F. The present proposal which is the first stage of development is to generate 3,00,000 kW at 60% L.F. with an installed capacity of 4,00,000 kW utilising only 2650 cusecs from the reservoir at Balimela. The completion of this project is expected to give a great fillip to the industrial development of vast tracts of virgin area in southern Orissa. Particularly it will help the development of the Dandakaranya Project area.

BHIMKUND AND THERMAL POWER UTILISATION SCHEME

By the end of the 2nd Plan period, all available generating capacity including that available as a result of integrated operation of the Hirakud system with the thermal station of the Rourkela Steel Plant would have been fully utilised and there would be no generating capacity left to cater to new load demands. These demands, therefore, have to be met by the proposed Bhimkund Project and thermal power stations. New transmission lines and feeders will have to be constructed by way of extending the present Hirakud system net work. Such extensions will have to cover 9 districts of the State viz., Keonjhar, Dhenkanal, Sambalpur, Sundargarh, Balasore, Cuttack,

Puri, Mayurbhanj and Bolangir. The 132 kV and 66 kV lines proposed for construction during the third Plan period have been indicated in the accompanying map:

132 kV D.C.	transmission lines	— 379 miles
132 kV A.C.	— do —	— 150 miles
66 kV	— do —	— 120 miles
33 kV	feeder lines	— 72 miles
11 kV	— do —	— 382 miles
25 kVA substations	89 numbers.	

132 kV substations at Khargpur, Bangiriposi, Joda, Sukinda, Jajpur Road and extensions to the existing 132 kV substations at Chowdwar and Chainpal are also contemplated. 66 kV. substations at Anandpur, Bhadrak, Balasore, and Betnoti are also proposed in the Bhimkund-Hirakud Grid.

MACHKUND POWER UTILISATION SCHEME

As in the case of Hirakud area, extension of the transmission and feeder net work in the Machkund area will be necessary not only to utilise the power available from the Balimela Project but also to interconnect the Machkund/Balimela generating stations, with the Hirakud system.

The extensions will cover three districts of the State viz., Koraput, Ganjam and Kalahandi. During the second Five Year Plan, only limited provision was made for transmission and feeder lines under the Duduma Transmission Scheme for utilising Machkund power. With a large number of lift irrigation schemes which have come up in this area and the progress of Dandakaranya Project, further extension of the transmission and distribution net work will be necessary and accordingly provision for construction of the following transmission and feeder lines is contemplated.

132 kV D.C. transmission line from Jeypore to Rayagada	— 67 miles
132 kV A.C. transmission line from Machkund to Jeypore	— 27 miles
132 kV A.C. (with provision for D.C. in future) transmission lines from Rayagada to Hirakud	— 206 miles
33 kV feeder lines	— 99 miles
11 kV feeder lines	— 100 miles
25 kVA substation	— 25

Provision for 132 kV substations at Kesinga and Bolangir and extensions to the existing 132 kV substation at Jeypore and Rayagada will also be necessary.

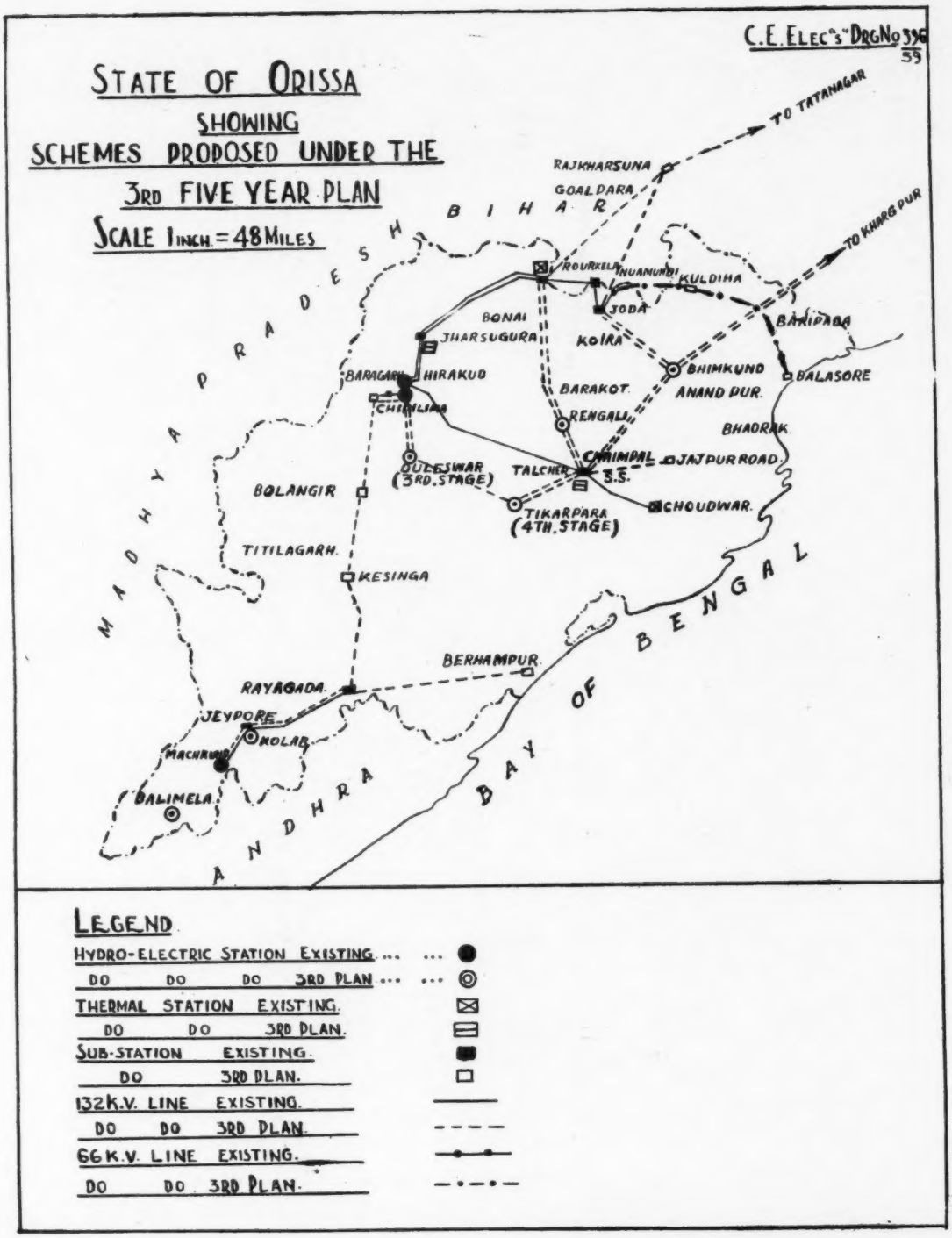
RURAL ELECTRIFICATION SCHEME

It was proposed to electrify 133 villages during the second Five Year Plan. Actually however, 63 villages have been electrified so far. Depending on availability of funds we may electrify another 50 villages before the end of the second Plan Period. In the third Five Year Plan period, electrification of 214 villages and small towns is contemplated.

It may be too much to expect that funds, foreign exchange and necessary technical personnel sufficient to carry through all the projects and schemes mentioned above during the third Plan Period will be available. It should, however, be feasible to take up and execute the most attractive projects and schemes which would fully meet the anticipated power deficit in the Hirakud and Machkund areas of the State involving an investment of Rs. 75 to 100 crores during this Plan period. From the investigations already carried out the projects and schemes that could be taken up are:

1. Bhimkund Project
2. Thermal Station at Talcher.
3. Balimela Project
4. Major portion of the transmission and distribution net work outlined earlier in this article necessary for utilising the power available from the three projects mentioned above.
5. Low Head Power Generation on the Canals.
6. Rural Electrification Schemes.

It is expected that at the end of the second Five Year Plan the per capita consumption in the State will be about 107 kWh. The implementation of the projects in the third Plan period is expected to increase the per capita consumption to 180 kWh. Even this figure is low compared to what will be achieved in the more progressive States of the country but still we have the satisfaction that we are on the path of progress. Greater achievement should be possible in the next Plan Period.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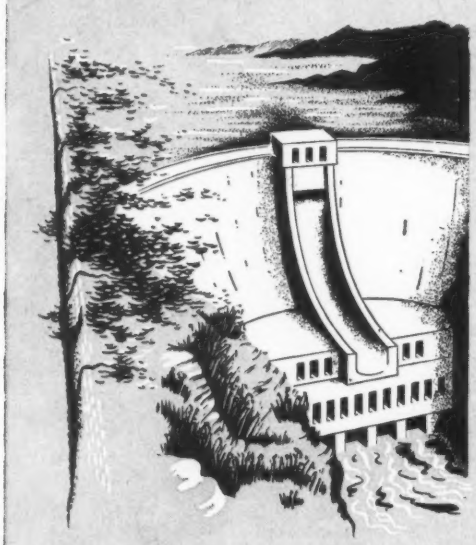

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Mahanadi Valley Development: Stages III & IV

by M. S. THIRUMALE IYENGAR

IN his report of 1947 on the Hirakud Dam Project Shri A. N. Khosla, the then Chairman of Central Waterways Irrigation and Navigation Commission had recommended proposals for unified development of Mahanadi Valley comprising—

(i) Hirakud Dam Project,
(ii) Tikerpara Dam Project &
(iii) Naraj Dam Project;

each with its canal system and Hydro-electric Power system. The three units were individually capable of independent development irrespective of whether the other two are constructed or not and of forming an integral part of the basin-wide plan.

As a first step the Hirakud Dam Project was sanctioned and work on this has been completed. The Chiplima Power House Project forming Stage II of Hirakud Dam Project is also on hand and is expected to be completed by 1961. The Delta Irrigation Project is also under execution.

However the best results will obviously be obtained if and when the entire valley is developed. But this overall development will take time before it is implemented in full. The proposal of 1947 for construction of Tikerpara Dam and Naraj Dam involves submergence of large areas of fertile lands and also pose a major problem of resettlement of the dispossessed people.

In July, 1956 the Government of Orissa constituted an expert Committee under the Chairmanship of Shri M. S. Thirumale Iyengar to recommend an order of priority for development of multi-purpose river valley projects under contemplation on the Mahanadi, the Brahmani and the Baitarni. The members of this committee were:—

1. Shri M. S. Thirumale Iyengar, Chief Engineer, Chairman.
2. Shri R. L. Narayanan, Chief Engineer, Electricity, Orissa.
3. Shri K. M. Bhatia, I.S.E., Additional Chief Engineer, Orissa.
4. Mr. C. M. Bennett, I.S.E., Chief Engineer, Orissa.

The Committee after study of all available data and the need for Power, Irrigation and Flood Control came to the conclusion that the order of priority for Valley Development should be as below:—

1. Bhimkund on Baitarni.
2. Rengali on Brahmani.
3. Tikerpara on Mahanadi.

As a part of the Baitarni development detailed investigations of the Bhimkund Dam have been entrusted to the Hirakud Construction Organisation. That Project report is now ready.

Although Tikerpara was allotted the third place, the possibilities of utilising the regulated releases from the Hirakud Reservoir after development of power at Chiplima and at the same time avoid submergence of lands has been engaging my attention. The recommendations of the French Mission on Mahanadi River for Navigation by construction of a lateral canal on the Right Bank of Mahanadi or a series of Weirs and the recent visit of the Gokhale Committee on Inland Water Transport have given rise to new thoughts and have resulted in the proposals now submitted.

THE PROPOSAL

The Scheme in outline consists of constructing either a weir across Mahanadi above Binka to pick up the regulated releases from Chiplima Power House or take the Chiplima tail race along the right bank for some distance, cross the Mahanadi at a suitable point by a Syphon and then take it in contour along the left of Mahanadi upto Dulesar a little above Boudhraj town on the opposite bank. A Power House at Dulesar would have a maximum head of 140′. Plates I and II shown here indicate the Alignment of Power Canal and "L" Section of Mahanadi. This scheme will also provide irrigation to over 60,000 acres. The channel will also be made navigable and with suitable locks at the weir and at Dulesar Power House boats can pass up and down the Mahanadi in this reach.

The installed capacity at this Power House would be of the order of 2,00,000 KW. This can be termed as Stage III of Mahanadi Valley Development.

STAGE IV

It is also possible to take the tail waters of Dulesar Power House along the Left Bank of Mahanadi by means of another Power Canal and drop it at Tikerpara obtaining a head of 90′. This can be termed as Mahanadi Valley Development Stage IV. The installed capacity at this Power House will be 1,24,000 KW. By means of this arrangement the scheme is executed in two stages as and when funds permit and demand for power grows.

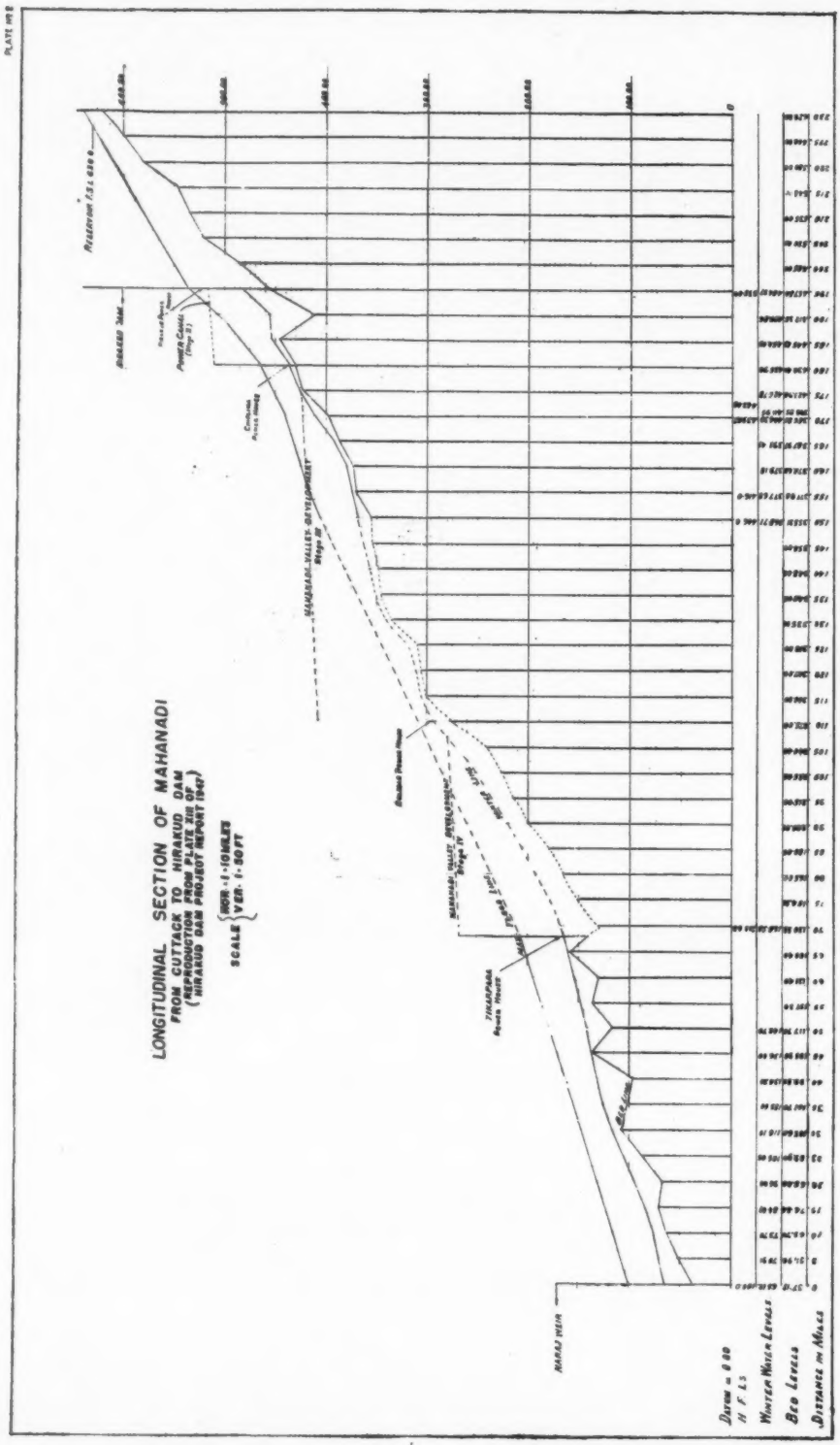
LONGITUDINAL SECTION OF MAHANADI
FROM CUTTACK TO HIRAKUD DAM
(REPRODUCTION FROM PLATE XIII OF HIRAKUD DAM PROJECT REPORT 1947)
SCALE HOR. 1 INCH = 10 MILES
VER. 1 INCH = 50 FT
Datum = 0.00 M.S.L.
Winter Water Levels
Bed Levels
Distance in Miles

Plate I : Longitudinal Section of Mahanadi

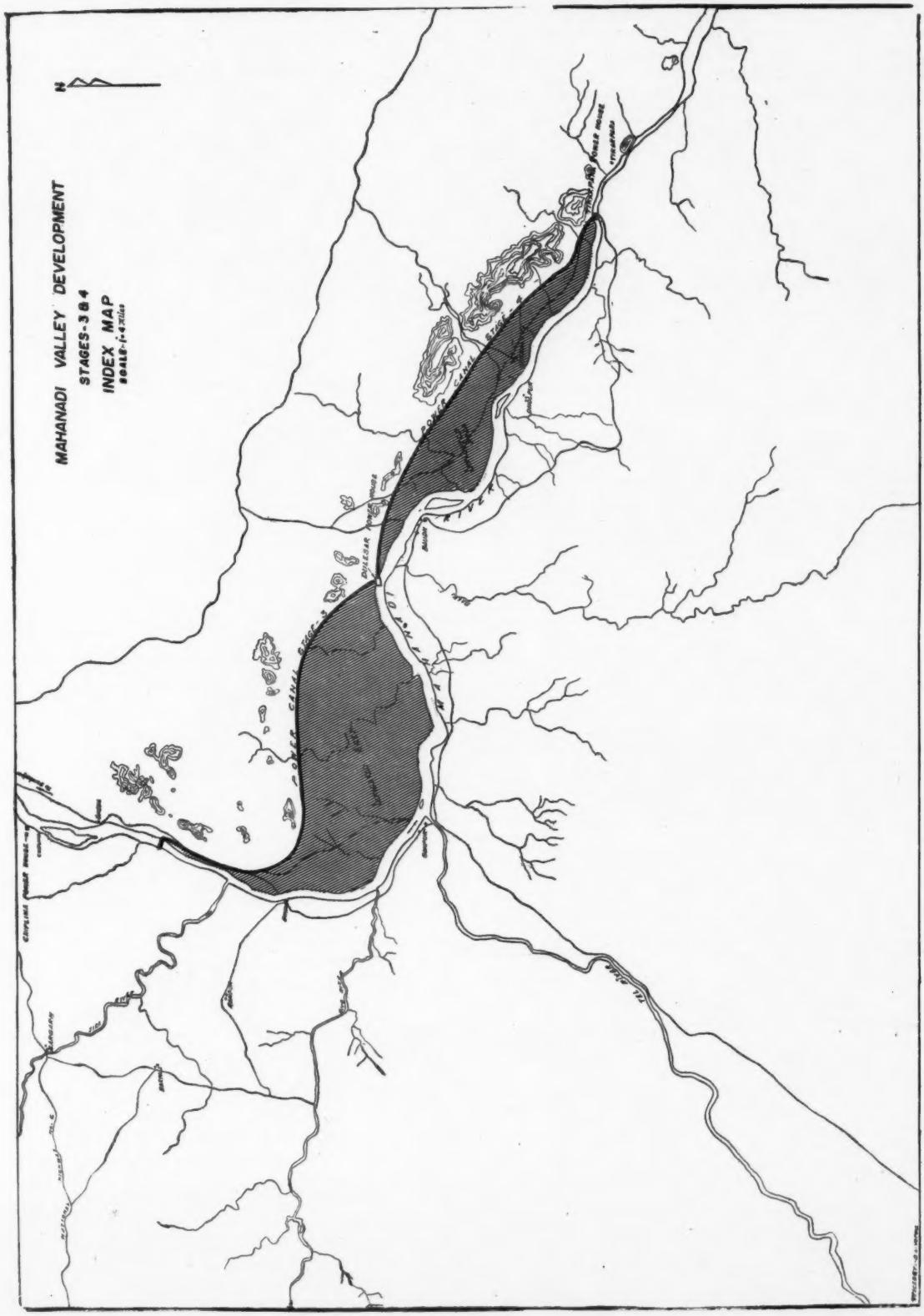

Plate II : Index Map of Mahanadi Valley Development Stages III & IV

Recently the Government of Orissa have sanctioned the Salki Irrigation Project in Phulbani District on the Right Bank of Mahanadi above Tikerpara. This would inter-alia indicate that the scope of Tikerpara Reservoir if and when it comes will be very limited. With the otherwise possibilities of Hydro-Power Generation as indicated above, the need for the construction of Tikerpara Dam and submergence of fertile rice growing lands and ancient towns like Athmallik, Boudhraj and Sonepur can be avoided. So far as Flood Control is concerned if necessary at all, it should be possible to construct one or more dams on the Tel River, a major tributary of Mahanadi. Experience of Hirakud Reservoir regulation in 1956 and 1957 has clearly indicated the enormous Flood Control potential at Hirakud and in my opinion, no more flood control reservoirs on the main stem of Mahanadi down stream are necessary. In 1957 dearth of a little flooding in the coastal regions is reported to have caused salinity of cultivated land.

ESTIMATES OF COST AND FINANCIAL FORECAST

A very preliminary and rough estimates of cost of the above proposals indicates that Stage III may cost 24 crores, and Stage IV Rs. 16 crores. These figures are only approximate. Detailed estimates can be framed only after field investigations are carried out. But the proposals are worth pursuing as cost per kilowatt installed will be only of the order of Rs. 1200 per KW in Stage III and Rs. 1290 per KW. in Stage IV.

The demand for power for development of Orissa's mineral resources is growing rapidly. The proposals enumerated above are simple, have no problems of rehabilitation and quick to execute.

(Continued from page 16)

THE BHIMKUND PROJECT: A GENERAL SURVEY

Meteorological Department to increase the number of Rain-Gauge stations.

6. The Central Water & Power Commission should be immediately entrusted with the job of preparing detailed specifications and drawings for the major structures of Stage I of the scheme. One Executive Engineer and two Assistant Engineers of the State Government should be deputed to Delhi to be associated with the preparation of the drawings of the Main Dam and appurtenant works. A Designs cell should also be created in the State P.W.D. for making the plans for irrigation canal structures and the like. This would enable proper working estimates to be prepared and kept ready for execution immediately finance is arranged.

7. Keeping in view the present objective for a Socialistic Pattern of Society and the importance of labour relations in management, I recommend that the Housing of the workers should receive very carefull attention by the project administration. Suitable tenements should be constructed for all workers and civic amenities like markets, schools, hospitals etc., provided. The standard of accommodation for officers and others should be on an austerity basis and the scale of accommodation should be purely utilitarian and according to the needs of the individual (size of family) with a little weightage for income.

8. Anti-Malarial measures for prevention and control at the dam site in the reservoir submersion area (very necessary because the land organisation & valuation staff will be intensively moving in the area), Power Canal, Power House and all construction sites should be undertaken six months in advance of the start of construction. This is very important.

9. Immediately the project is sanctioned, area should be notified and brought under Municipal or other civic laws to avoid growth of unsightly, unhygienic and unauthorised structures by traders, contractors etc., as has happened in the steel plant area at Rourkela and a few other project sites. A carefully thought-out plan for the township should be prepared in advance of the project construction.

10. There are some good technical personnel of Orissa State P.W.D. trained at Hirakud for the construction job. But those will not be enough where such large construction is envisaged. The administration will have to take suitable men from different parts of the country, to reinforce the local talent. In order to attract the best available talents and keep them contented it is necessary that the State Government while fixing the terms of appointment of such persons also include a clause allowing leave travel concession to enable them and their families to visit their home once at least in two years.

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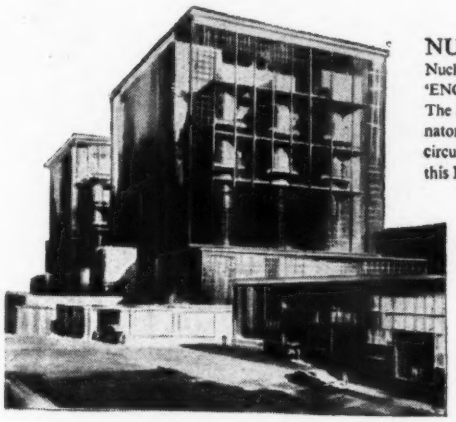
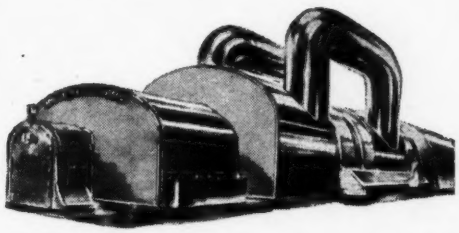


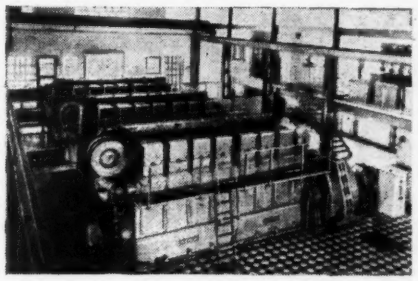
NUCLEAR. The first 500 MW Atomic Power Station (the world's largest Nuclear station) is under construction at Hinkley Point, U. K., by the 'ENGLISH ELECTRIC'—Babcock & Wilcox—Taylor Woodrow Consortium. The English Electric Company is supplying six main 93.5 MW Turbo-Alternator Sets, three 33 MW Variable Speed Turbo-Alternator Sets and a fifteen-circuit 275 kV duplicate Busbar Switching Station. The Reactors to be used at this Power Station will be of 'ENGLISH ELECTRIC' design.



STEAM. One of five 200 MW Steam Turbo-Alternators which the Company is supplying for the High Marnham Power Station, U. K. Early this year the Company received an order for two 275 MW Steam Turbo-Alternators for the New Blyth Power Station, U. K., and the sets are the two largest in-line turbo-alternators of their kind (50 cycles) in the world.

HYDRO. One of two 37.5 MW Water Turbine Generating Sets installed at Hirakud Power Station, Orissa. In the past 10 years the Company has supplied the entire plant for four major hydro-electric stations in India—Radhanagari, Nizamsagar, Sarda and Sengulam, and is manufacturing five—50 MW Water Turbine Generating Sets for the Rihand Power Station, U. P.

'English Electric' high rupturing capacity switch and fuse distribution equipment is now being manufactured in our works at Madras.



DIESEL. Three 'English Electric' Diesel Alternator Sets installed at Saateni Power Station, Zanzibar. The total output of the engines is 3,936 B.H.P. at 375 r.p.m. and the Station supplies the Island with a large part of its electricity.

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9/F/109

The Bhimkund Project: A General Survey

by M. S. THIRUMALE IYENGAR

MAHANADI, Brahmani and Baitarani are the three major rivers traversing the Orissa State. The completion of the Hirakud Dam across Mahanadi marks the first phase of river valley development in the State. With the steel, aluminium and ferro-manganese going into full production by 1961, there is no power left in the Hirakud system that will permit the expansion of these industries, which is bound to take place gradually. Aluminium expansion has vast possibilities. The present 20,000 ton production programme can easily be expanded to 40,000 and even 60,000 tons if power is available and so will steel and ferro-manganese expand in course of time. A lot more power generation by 1965 or 1966 seems inevitable. The D.V.C. power system is reported to be growing very fast and the likely demand by 1965-66 is said to be 1,000 MW. and all this power will have to be only the costly thermal generation. They need not expand the thermal generation if Hydel Power is available close-by. So West Bengal, Madhya Pradesh, Railways and even Bihar must look to the vast cheap Hydro power potential of the Orissa State for their requirements.

Attention must therefore naturally be focussed on further development of river valley resources in Orissa State for large Hydro Power production. As part of the Mahanadi Valley development investigations had been carried out at Tikerpara and Naraj in the lower reaches of the valley. However, construction of Tikerpara Dam, though it has large power potential. has certain serious disabilities. It submerges very fertile paddy growing land and important towns. The extent of irrigation development below is also extremely limited. Of course the construction of this dam would afford almost a full measure of flood control and protection to the delta. How far a complete cessation of flooding of lands would affect land fertility is a point to ponder. The government of Orissa set up a Committee under my Chairmanship in July 1956 to study the various multipurpose river valley projects under contemplation in the State and recommend the order of priority for their detailed investigation and execution. The other members of the Committee were (1) Sri R. L. Narayanan, C.E., Electricity (2) Sri K. M. Bhatia, Additional Chief Engineer, Irrigation and (3) Sri C. M. Bennett, C.E. After studying all the technical data relating to the several projects and examining the power, irrigation and flood control potential of the schemes, the Committee gave priority to the Project on the Baitarani river. And as the Government of Orissa did not have requisite technical personnel to take up the investigation of the project on the Baitarani river, they entrusted this job to the Hirakud Project organisation. Detailed investigations for a scheme on this river were carried out between February 1957 to June 1958.

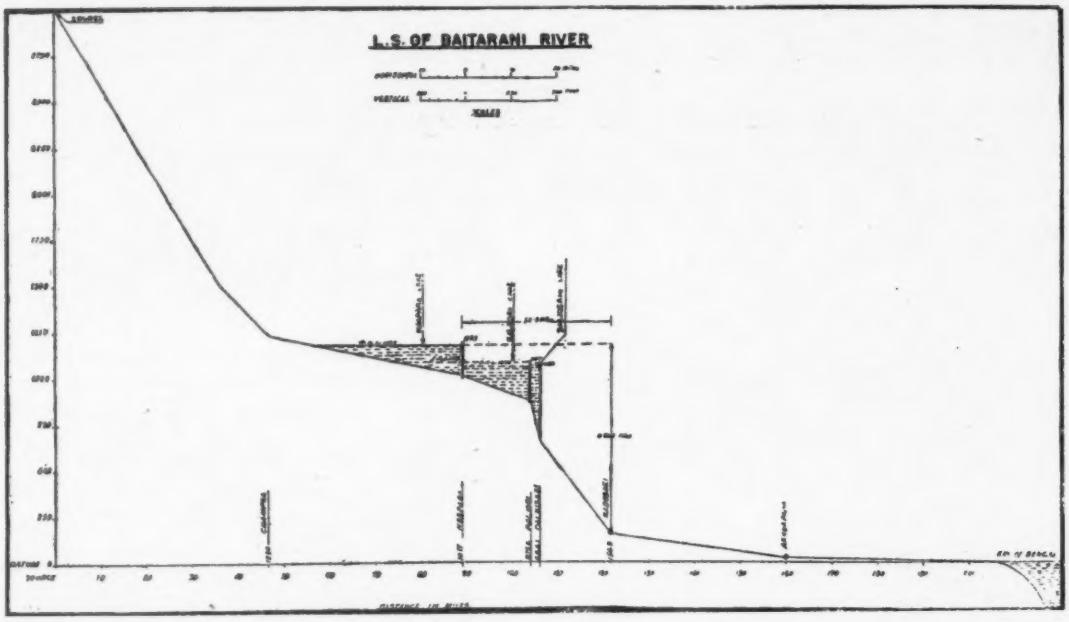
CHOICE OF SITE

Bhimkund is the name of the Falls in the river Baitarni. At a short distance below the Falls the river passes through a 150′ narrow gorge. The CWPC (Power Wing) while making an assessment of the power potential in the eastern zone with the aid of the topographical maps, pin-pointed the site at Bhimkund as suitable for a storage reservoir—principally for power generation. From the map contours, the Commission made a preliminary survey of the power potential and visualised the possibility of developing 160,000 KW. utilising nearly an aggregate 700 ft. drop in the river, requiring an effective capacity of 105,000 m.cft. (2.42 m.a.ft.).

Besides this power potential, there are other purposes served by a reservoir on the Baitarani. This river also is one that comes down in enormous uncontrolled flood devastating homes and property in the valley lower down. A reservoir on the main stem of the river is necessary to control the floods in the basin. Incidentally, the water that passes through the turbines can be used for augmenting food production by development of vast extent of agricultural land in the valley.

The Baitarni river rises in the hills of Keonjhar District in Orissa and after flowing a length of 224 miles, first in a southwesterly and then in an easterly direction, joins the river Brahmani and the combined stream known as Dhamra falls into the Bay of Bengal.

See the condensed LS of the river. Three sites were investigated—the Dalkisahi, the Balijori and the Noapara. Dalkisahi was obviously found unsuitable, on account of the height of the dam being excessive for the storage required. It is a deep gorge formed by a series of rapids which register a fall of 185 ft. in the course of 3 miles and 535 ft. in the course of the next 15 miles below Balijori. Balijori is at the head of the steep rapids and this site was next investigated as the height of the dam for the requisite storage was in the region of 200 ft. The bed fall of the river



above this site is 11′ per mile from a place called Noapara. Noapara at the head of this steep reach and at the base of a long reach that registers 4′ per mile, is obviously the site if it contained the ingredients for storage, good foundation and not unreasonably and unduly high extent of submersion of lands and houses. It would also give the maximum drop for power production. That was the third site investigated and found most suitable and promising.

Half a mile below Balijori the river has a sudden drop of 22 ft. and this fall is popularly known as "Bhimkund" falls. At Kadobari on the river at the foot of the rapids the level is + 150. From Kadobari to Akhuapada, the bed fall is 2.5 ft. per mile. At Akhuapada the river throws off branches forming a small delta and the rivers are all tidal.

The maximum height of dam at Dalkisahi would have been 355 ft. for 1.4 million acre feet storage. In the flanks the drilling that was done disclosed disintegrated rock to nearly 50′ depth. The entire length of earth dam would have needed extensive foundation treatment. The cost of power generation also worked out to more than Rs. 3,500 per KW. The storage of 3.4 million acre feet would mean a 400′ high dam and more difficult foundation problems.

The site at Balijori half a mile upsteam of the Bhimkund falls would mean a maximum height of dam of 200′ for a 1.4 million acre feet capacity. While the foundation in the river bed and flanks presented no particular problem, the quantity of earth work involved in the flanks was almost the same as for 'Dalkisahi' site. The river falls being as steep as 11 ft. per mile above this site, greater storage would be possible only by a very much higher dam. The site was not considered as unsuitable and perhaps would have been selected if a better one suitable for maximum utilisation of water resources had not been found.

But such a one was found. The site at Noapara about 12 miles above Balijori is comparatively a much better site for a 3.4 million acre feet capacity. The foundations are good in the river bed. The maximum height of dam for 1.5 million acre feet storage is 150 ft. and for 3.4 million acre feet, it is only a 180 feet. The quantity of earthwork involved in the flanks is less than that of the other two sites. The submersion of land is however a little more and it also necessitates the re-location of a part of the Calcutta-Bombay National Highway. But the Noapara site has the great advantage over the other two, in being the only site that permits utilisation of the maximum hydro-power potential of the Baitarni river.

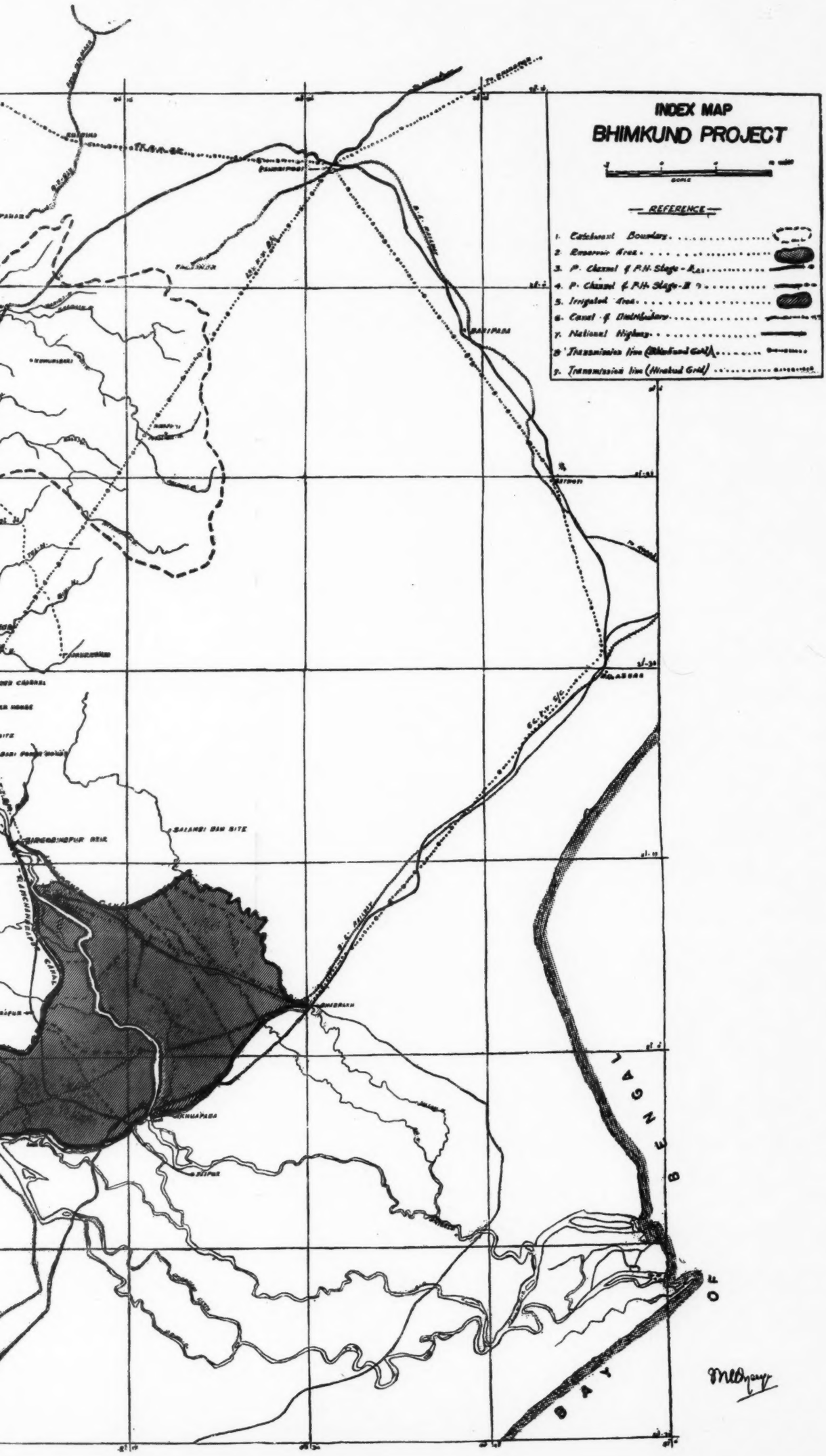
PROPOSALS

After detailed investigations, it is proposed to develop the basin for:

(1) A dam with Reservoir of 3.4 m.a. feet capacity.
(2) A power plant at the dam with installed capacity of 2 units of 28 M.W. each.
(3) 3 Power Houses lower down to utilise the head available upto Kadobari with an aggregate installed capacity of 422 M.W.
(4) Irrigation of 3,10,000 acres of land.

Power and Irrigation development are however capable of a stage plan. The project can be conveniently divided into two stages.

Index Map of Bhimkun



of Bhimkund Project

Chief Engineer, Hirakud, and party at the time of first visit

Stage I will comprise:—

(1) Noapara Dam with Reservoir of 3.4 m.a. feet capacity.

(2) Power plant at Dam with installed capacity of 56 M.Ws.

(3) A diversion Weir at Balijori and 10 miles Power Canal in Left Bank ending in a large Forebay from where the water will be dropped 670′ for power generation at the Main Power House at Baigundi. The installed capacity will be 6 units of 55 M.W. each for the present.

(4) In this stage, the Bhimkund grid will be connected to Hirakud at Joda and Chowdwar and Bengal grid at Kharagpur by 132 K.V. Transmission Lines. Power will be supplied at Sukinda, Anandpur, Bhadrak, Balasore by 66 K.V. Transmission Lines and finally the line will join Hirakud grid at Betnoti.

(5) The water released from Main Power House will be picked up at Birgobindpur by a pick up Weir and will be diverted in the Left Flow Canal to irrigate 1,05,000 acres in Anandpur and Bhadrak Sub-Divisions of Keonjhar and Balasore Districts. Similarly a canal will offtake in the Right Bank to irrigate 73,000 acres in Anandpur Sub-Division and Jajpur Sub-Division of Keonjhar and Cuttack Districts

Stage II will comprise of:—

(1) Utilisation of the head available between Dam and Balijori Weir for power development by putting up a diversion Weir 4 miles below the dam and a 7 miles long canal on the Right Bank ending in a Forebay at village Hatinata where Power House No. 2 (Hatinata Power House) will be located and a tail race channel cut to the river.

(2) A "run of the river" station to utilise the head available between the Main Power House and Kadobari by diverting the flow by a Weir below Bara Nala and dropping it at Kadobari. The Power house can be located near the Kadobari village.

(3) Installation of the 7th unit of 55 M.W. in the Main Power House at Baigundi.

(4) Extension of irrigation below Akhuapada and surplus water diverted to Salandi system for Rabi Irrigation. Lift Irrigation can also be provided in Anandpur Sub-Division to cover 10,000 acres.

The above proposals in the II Stage—particularly the power side of it require some detailed investigation to determine the maximum power potential at the Hatinata and Kadobari power houses. The possibility of utilising the extra water in the rivers in

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these two "run of the river" stations is an attractive feature.

RESERVOIR CAPACITY

The topography of Baitarni river lends itself for developing a huge block of hydro-power. The fall in the river from Noapara to Kadobari is over 850'. This coupled with the head in the reservoir at Noapara would mean a potential head of 1000' for power development. It is therefore essential that any scheme for development should aim at the optimum utilisation of the Baitarni waters taking advantage of the great fall.

Hydrological studies of records since 1905 indicate that a minimum inflow of 1.4 million acre feet will be available in all the years, 2.2 M.A. ft. in 80% of the years and 3.4 M.A. ft in 50% of the years. The storage required has also been analysed from a mass curve for the worst period of inflow (1949-1956). It is observed that reservoir with a 'carry over' from good years would yield the optimum power benefits. Of course there is a limit to such carry over storage. Beyond a particular point it becomes uneconomical i.e., cost of storage and generation would be high. An annual utilisation of 2.5 M.A. ft. is found to give the optimum results. For this utilisation to be successful in over 95% years, the storage has to be 3 M.A. ft. With a silt reserve requirement of 0.4 M.A. ft. the gross storage comes to 3.4 M.A. ft.

THE NOAPARA DAM

The Noapara Dam, as proposed, will be of composite design—masonry spillway and non-overflow sections in the river bed portion, and earth dam and dykes in the flanks and saddles. The river channel is only 850' wide. A spillway 700' long will be located within this section. There will be a non-overflow masonry section to the right of this 1550' long followed by an earth dam 6150' long. On the left there will be a non-overflow masonry section 1200' long and earth dam 5400' long beyond it. The Main Dam will thus be 15000' long accidentally coinciding with the length of the Hirakud main dam.

The Right Dyke will be 9000' long and the Left Dyke 12500'. The Noapara Dam will thus have a total 36,500' length. The maximum height of masonry dam above foundation will be 192'. The maximum height of earth dam 110'. Although the over all length of the dam is 36,500', only about 8000' length is in excess of 100' height.

The average bed level of the river is +1020.00 and the deepest foundation level anticipated is + 1000.00.

The foundations have been explored by drill holes. The rock in the river channel is observed to be closely jointed and does not indicate any deep fissures or faults. Trial pits put in at periodical intervals on the earth dam alignment, have indicated impervious strata at reasonable depths.

The spillway is proposed to be the "Ogee" type surmounted by $14 \times 40' \times 40'$ radial gates. These gates can be manufactured within the country in the 'Tungabhadra' Workshops who are manufacturing similar gates for Kotah Barrage in Rajasthan.

The earth dam and dykes are proposed to be of the rolled fill zonal sections of impervious and semi-pervious material. The front and rear slopes are designed to 3:1 and 2:1 respectively. Suitable berms, filter blankets, rip-rap and rock toe have all been provided. The dykes will however be of a homogeneous section.

The dam will carry on top of it the diverted National Highway. The road-way will be 22' wide. The Spillway is designed to pass a flood of 5,00,000 cusecs, at F.R.L. 1180.00 The capacity of the reservoir will be 3.4 M.A. ft. out of which the live storage is 3 M.A. ft. The maximum area of the water spread at F.R.L. will be 125 sq. miles. It is a "carry over" reservoir for optimum power potential purposes.

Construction of Noapara Dam would mean placing 47.68 million Cft. of concrete and masonry, 316.5 million Cft. of earth, 2.9 million Cft. of sand in filter and 1.07 million Cft. of shingle. There would also be 29.9 million Cft. of rock fill and rip-rap to be done.

The stability computations for the various sections of the dam have all been made and are found explained in the detailed report.

During construction, it is proposed to divert the non-monsoon flow through low level construction sluices $8' \times 10'$—two in number. These construction sluices will either be plugged, or retained to draw-off the dead storage for developing extra power in II Stage "run of the river" stations.

SUBMERSION OF LAND AND RESETTLEMENT

For storing 3.4 M.A.ft at Noapara the F.R.L. should be 1180. At this level the lake will submerge 80,000 acres or 125 sq. miles. The entire land is, however, in Orissa State only and so will not present any inter-state problem. The reservoir will not submerge any known valuable mineral deposits. It is estimated that about 50,000 people would be displaced (10,000 families) cultivable land affected is estimated at 32,000 acres. The displaced people can be resettled in the Thakurmunda area of Keonjhar district where the population density is only 50 per sq. mile. In addition some can be settled in marginal lands above the Reservoir. The question of evacuation of submerged villages and their resettlement is, therefore, not expected to present any major problem. The estimates provide for a fair and reasonable compensation and resettlement charges.

POWER DEVELOPMENT

Several alternatives were considered regarding utilising the head between Noapara and Kadobari for power development. The question of taking a power

canal right from Noapara Dam to the main power house at Baigundi below the falls and rapids was examined. It was found that such a canal would be about 25 miles long involving costly maintenance and operation. In the Head reach, it has to cross numerous Nallahs and a few major streams. Cost studies indicated that a weir at Balijori and Power Channel therefrom is cheaper. Also this arrangement would permit greater flexibility in operation and take advantage of any inflow into the river between the dam and Balijori. A power channel from the right flank at Balijori taking off at R.L. 902 F.S.L. and 8 miles long to a point on the hill upstream of the confluence of Sitanadi with Baitarni was also investigated. The cost of the canal will be 4.5 crores but the drop for this is only 570′. A left bank power canal at about the same cost is found affording greater drop and has, therefore, been proposed. It is suggested that the power potential between Noapara and Kadobari be developed in 4 stages. The Main Power House will be situated at Baigundi, 9 miles below Bhimkund falls for a 670′ head. The power canal will take off from the weir at Balijori 1080′ long with its crest at R.L. 902.00. This weir would be solid masonry with no crest shutters. It will have only some deep sluices on the left flank to act as scouring sluices that will keep the approach to the power canal head regulator clear of silt and other rolling bed material. The power canal on the left bank will be 45,000′ long and is designed to carry a maximum discharge of 4000 cusecs. It will be lined throughout its length. Six units of 55,000 KWs each are proposed to be installed in the first instance in the main power house. Provision is, however, made for installation of another unit later.

There would also be a power house at the foot of the dam with 2 units of 28,000 KWs. each. In Stage II Project development, two more power houses—(run of the river stations) one to utilise the fall between the dam and Balijori Weir and another the fall in the river between main power house and Kadobari will be built.

The installed capacity under Stage I will be 3,86 MW. Firm power at 60% load factor being 3,00 M.W.

A large block of secondary power can also be generated during monsoon months that can flow into the Eastern grid for utilisation.

IRRIGATION

The regulated releases from the Main Baigundi Power House are proposed to be picked up at Birgobindpur 5 miles up-stream of Anandpur by constructing a barrage 930′ long. The Barrage will have 14 vertical lift gates of 60′ × 20′. Such size gates have been fitted over the Tungabhadra Dam crest and were manufactured in the Tungabhadra Workshops. A bridge will be provided over the barrage with a 12′ roadway. Two canals one on the left and another on the right will take off from the barrage. The left canal named as 'Anandpur canal' will be 84,000′ long, carry a discharge of 1230 cusecs at its head and irrigate a culturable commanded area of 1,05,000 acres. The right flow canal named as 'Ramachandrapur Canal' will be 93,000 ft. long and carry a discharge of 900 cusecs at its head. This will irrigate a culturable commanded area of 73,000 acres with double cropping over 50% of the C.C.A. the actual area irrigated in Stage I will be 267,000 acres.

As part of Stage II development, irrigation can be extended below Akhuapada and also diverted to Salandi system for developing Rabi cultivation and further extensions.

FLOOD CONTROL

Although the Baitarni is a small river compared to Mahanadi and Brahmani, it brings very heavy floods causing extensive damage and havoc. During the last 75 years it is reported that more than 20 damaging floods have occurred. During 1925 to 1927 floods occurred every year. During the decade from 1895 to 1905 every alternative year the flood rose above the danger level. The great flood of 1927 washed away several miles of Bengal-Nagpur Railway (now S. E. Railway) line. The construction of Bhimkund Reservoir will, therefore, provide a good measure of Flood Control in the valley.

MATERIALS OF CONSTRUCTION

The spillway and masonry dam will be of rubble stone in red cement mortar. With the over-flow rear face formed with dressed stone as has been done in Tungabhadra, the Lakkavalli and end sections of the Hirakud Dam Spillways. Hard, dense and durable granite is available in close proximity of the dam and Balijori Weir sites. There is considerable stone in the bed of the river itself for some distance which lends for quarrying extensively for the building stone. River shingle is also available within 6 miles from the dam. But most of the requirements of aggregate for concrete and filter blanket will have to be obtained by crushing stone.

Sand is available only at the mouth of Deo Nadi about 10 miles from the Dam site. The economy of crushing rock for use in lieu of sand has to be examined.

Cement has to be obtained from Rajgangpur or Jhankipani (Chaibasa).

The soil surveys conducted indicate that adequate quantities of semi-pervious and impervious earth are available within a lead of 3 miles from the dam.

Soil suitable for 'surkhi' to be used as a pozzolanic admixture with cement is also available nearby.

The Hirakud Research Station has conducted tests on all materials.

MACHINES REQUIRED FOR CONSTRUCTION

Enough earth digging, hauling and compacting equipment is available from Hirakud for making the earth dam in the flanks of the masonry dam sections. And for the masonry dam we need only power mixers for manufacture of red cement mortar and some disintegrators for manufacturing surkhi—all of which are available in the country and most of them in the Hirakud Stores.

Crushing equipment is also available. Thus no foreign exchange for equipment other than the electrical power generating equipment is required.

The Hirakud workshop is equipped well enough to manufacture all other mechanical gadgets and steel fabricated structures needed during execution. The workshop manufactures sheep foot rollers and has a good foundry for casting. The enormous stores containing some 50 or 60 thousand items afford opportunities for improvisation of several constructional needs.

PROGRAMME OF CONSTRUCTION

This scheme is very attractive in that its several components can be built in stages and benefits obtained quickly. The two stage plan is attractive and has popular features. Stage I can also be split up and developed in several sub-stages. For example, the construction of the Balijori Weir, Power Canal and Main Power House can be done first and a large block of power developed although during summer months the system may require support from other sources. And as we raise the dam the storage will go to improve the power production. The installation of the units in the Main Power House can also be in stages. The Power House at Dam site can be put in as and when the load develops. The Noapara dam construction can also be phased according to needs and demand for power. The construction of the irrigation weir and canal system can be tackled separately and according to the resources available.

According to the programme of construction drawn up and presented in the report, the dam is scheduled to be completed in 9 years. Power generation and irrigation will, however, commence in the sixth year itself. The programme is so drawn up that at the earliest opportunity, the project starts yielding revenue, and the revenue can be ploughed back for further investment.

In this connection I would like to invite particular attention of the State Government regarding advantages of making certain preliminary arrangements at the dam site such as approach roads, colony lay-out, water supply and sanitary systems etc., out of the State funds in the first instance. These early arrangements generally give a two-year start in construction. If between the time of consideration of the project by several departments of the Government of Orissa and the Government of India and Planning Commission the State Government completes these preliminary works, they would help speeding up the construction when the scheme is sanctioned.

ESTIMATES OF COSTS AND FINANCIAL RETURNS

Stage I of the Proposals is estimated to cost Rs. 61.73 crores. This is based on present trend of rates for labour, material and power plant equipment. The break up of this figure is:—

	Crores
Dam and Appurtenant Works ...	Rs. 29.95
Power Plant & Transmission Lines ...	Rs. 27.71
Weir and Canal system ...	Rs. 4.07

The financial statements and Revenue returns have all been worked out. The cost of dam has been allocated only between Power and Irrigation as the Project is essentially a Hydro-Electric Scheme and flood control is only an incidental benefit. Power Revenue is based on a flat rate of Rs. 164/- per kilowatt year. For irrigation it is proposed to levy betterment fee and water rates.

The returns anticipated are

Power	11 %
Irrigation	2.9%
Combined Power & Irrigation ...	9.9%

There may be slight changes in these figures based on actual rates of development and rates at which power will be sold, but it can be said without hesitation that Bhimkund will be one of the soundest investments in India and easily qualify for financial assistance from any institution, national or international.

RECOMMENDATIONS

1. The Bhimkund Project (Stage I) should be sanctioned forthwith. It is very attractive, has popular features and will pay handsome returns.

2. Immediate steps should be taken to decide the programme and policy for resettlement of the people whose lands will be submerged in the proposed reservoir.

3. Steps should be taken to build a good road (preferably asphalted) to the Noapara dam site from State funds.

4. The Central Water & Power Commission (Power Wing) has been requested to carry out a systematic electric load survey. On receipt of this report the State Government should formulate an overall development plan for the Bhimkund area..

5. The State Government should make arrangements to continue the hydro-meteorological observations on a permanent basis. They should move the

(Continued on page 10)

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INDUSTRIAL PRODUCTS DEPARTMENT

PSIP 6

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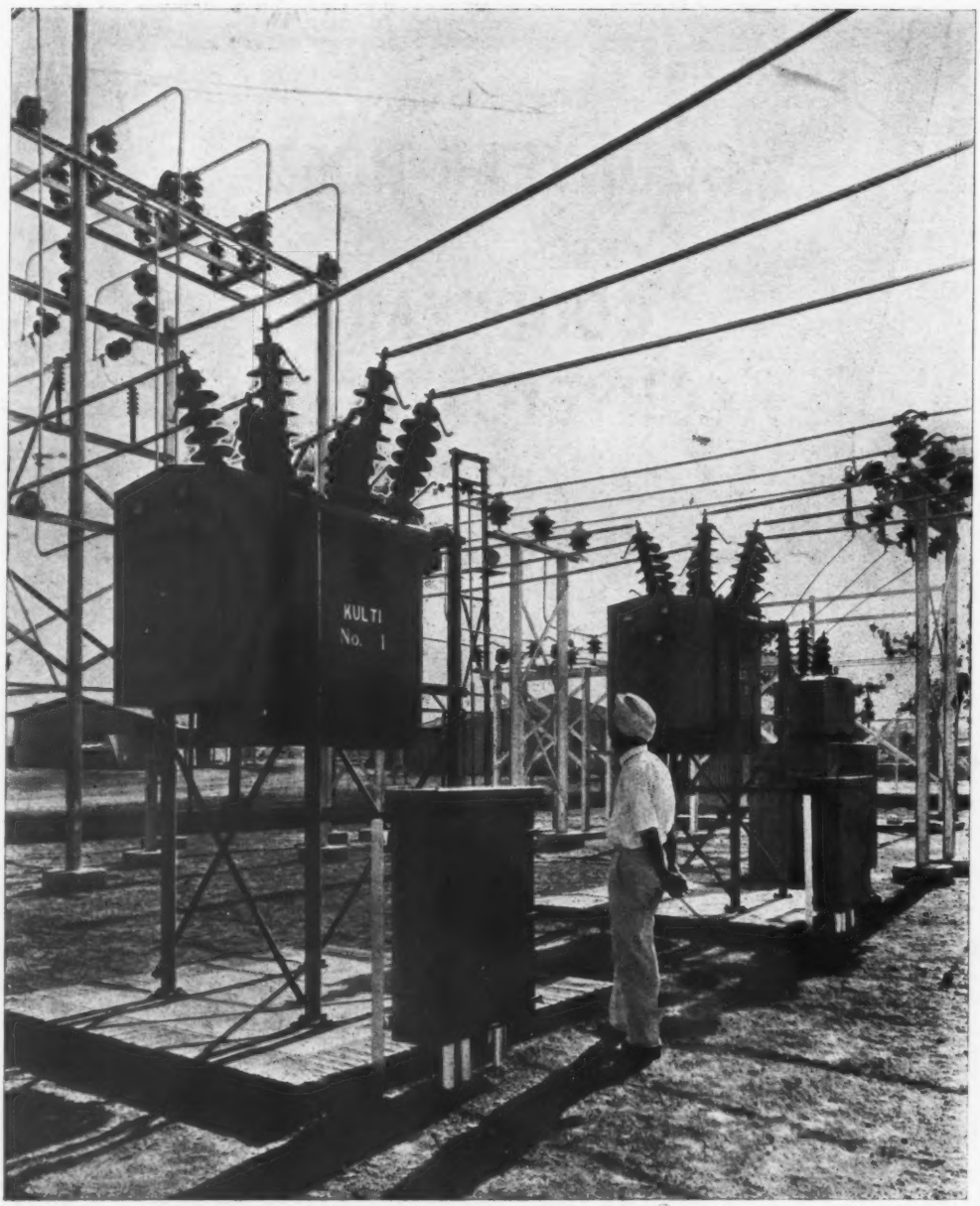

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Power Development in the Bhimkund Project

by N. DHARMARAJAN

THE longitudinal Section of the River from Champua to Kadobari was taken. Various power canal proposals were surveyed by block levelling about 1000′ on either side of approximate alignment and final alignment was located on these maps.

ALTERNATIVE METHODS OF DEVELOPMENT CONSIDERED

All the alternatives surveyed involved four Power Houses and a Power House below Dam was common to all proposals. The Tail water level below Dam is +1020 and a Canal from the Tail-race of Power House below Dam with +1020 at head can not be carried beyond Bhimkund Falls as ground conditions do not permit. Hence a Power House at Bhimkund Falls is unavoidable. This could be located either in Left or the Right bank. The Right bank was selected as the number of drains are less, the canal is shorter and the alignment goes in easy country.

Below Bhimkund Falls either (1) the Canal could be taken in Right bank and dropped at Sita Nala or (2) it could be taken in the Left bank and dropped opposite Bajalpur. The Canal proposed in alternative (1) would have to cross a 'V' shaped depression about 70′ deep & 2000′ wide and after the depression it has to go either in steep side hill cut or through a tunnel. Alternative (2) involved a Diversion Weir at Balijori (half mile above Bhimkund Falls) and aqueducts over Sim and Kantamuli. Besides in the head reach the canal has to go through a 70′ deep cutting.

For Alternative 1, the maximum head available is 570′ and for alternative 2, the maximum head is 670′. In both the alternatives the balance of head was to be developed by another Power House lower down.

In Alternative 1, all the Power Houses would have

Sita Nadi Power House site

Main Power House site

been on Right bank and communication would not have involved bridges over the main River.

Thus alternative 1 & 2 were proposals with equal advantages more or less.

But alternative 1 does not have a large Forebay. The Foreby area in alternative 1 is 30 acres whereas the Forebay area in alternative 2 is 420 acres. This is a large Power Station and practically all the peaking will be done in this Power House. Hence alternative 2 has been preferred.

A brief mention is made of alternatives suggested by C. W. & P. C. from a study of maps along with proposal for location of Dam at Dalkisahi.

The proposals were (a) a single underground Power House or (b) two Power Houses over ground opposite village Kadobari. They had suggested +950 as off-take level of the Canal (from the proposed Dam at Dalkisahi). With the change of Dam site, the off-take level could have been +900 as any level higher than +900 would have involved a higher diversion level for the Weir. Tail water level available is +230 and these proposals would have given the same gross head for a longer Power Canal and more difficult construction.

With the location of Power House at Bajalpur, the balance of head remaining to be developed is 80′ (+230 to +150). This can be done by (1) Dam at Kadobari and Power Plant below Dam or (2) by a Canal off taking below Bar Nala where a Diversion Weir will divert the flow to the Right bank. This has to be a base load station so that a regulated steady release is let down for irrigation drawal lower down. Besides the Forebay for this Power House should be large to avoid excessive head loss in main Power House during peaking. Hence proposal (1) will be better though proposal (2) will be cheaper. This is not included in the present proposals.

POWER POTENTIAL ON FULL DEVELOPMENT AND IN STAGE—I

A working table has been prepared to arrive at a constant Power output with discharge varying from 3300 Cusecs to 3100 Cusecs and aggregate nett head varying from 1000′ to 935 ft. This gives a Power output of 2,20,000 KW. at 100% load factor for 98% of the years. For Stage I the power output is

$$\frac{3200 \times (650+140)}{14} = 180 \text{ MW. at } 100\% \text{ L.F.}$$

PRESENT PROPOSALS

A power plant below Dam does not involve any extra civil works and the only expenditure is on Power House & Plant. The Main Power House is a

Dalkisahi Dam site looking downstream

high head plant and even with 1,00,000 acre feet storage, it will be possible to generate 80 MW. within five years of construction and thus will yield good returns with minimum investment. Besides these two Power Houses will meet the anticipated demand.

The Noapara Power House and the Main Power House have therefore been included in Stage 1.

POWER DEVELOPMENT AT NOAPARA POWER HOUSE

(1) *Hydraulic particulars:*

Maximum daily average Discharge ...	3300	cusecs.
Minimum head ...	100′	
Minimum daily average Discharge ...	3100	cusecs.
Maximum head ...	160′	

(2) *Power available:*

For maximum head conditions in the Dam the maximum power output is 35,000 kW. at 100% LF. or 59,000 KW. at 60% LF.

(3) *Installed capacity:*

It is proposed to instal 2 Units of 28,000 kW. each.

(4) *Power House:*

The Power House will be located in the Right bank adjacent to the River bank and will be protected from the flood by the training wall on the Right side of Spillway. The approximate spacing of units will be 57′ and adding extra 75′ for repair bay, the overall length of the Power House may be 189′ or 190′. The width of the Power House may be 50′.

(5) *Penstocks:*

2 Steel Penstocks of 20′ dia. and 1″ thickness are provided. Maximum velocity allowed is 12.5′.

(6) *Excavtion limit for Draft Tube:*

The minimum excavation depth is assumed as 55′ below +1020 (Tail Water Level).

(7) *Switch Yard:*

This will be located in the space to the Right of Power House which will be levelled up with excavated material from Power House and Dam Excavation.

(8) *Trash Rack:*

Semi-circular trash rack structure of 20′ dia. will be built in R.C.C. and locally manufactured gratings will be fitted.

(9) *Estimates:*

There is nothing special to mention about the estimates.

No provision has been made for K-Buildings, as this work will be taken up by 7th year when sufficient buildings will be available at Dam site, Power House and Plant have been estimated at Rs. 100/- and Rs. 300/- per kW. of installed capacity. Other items are based on details of quantity.

POWER DEVELOPMENT AT THE MAIN POWER HOUSE

(1) The following major works are required for Power Development at Main Power House.

(A) A Diversion Weir at Balijori.
(B) A Power Canal 45500′ long off-taking from the Left Bank of Balijori Weir.
(C) Forebay.
(D) Penstocks.
(E) Power House and Machines.

The works are described below under A to E.

A. DIVERSION WEIR

Location:—The Weir is located at the same place where originally the Dam was proposed. The site is half mile upstream of Bhimkund Falls.

Economic Diversion Level:—A Level of +900 was found suitable, as at this level it was possible to limit the cutting and filling of the Canal to 50′ except for a short length in the Ridge between Sim and Kantamuli Valley.

Maximum Flood Discharge:—The maximum release from the Dam is expected to be 5,00,000 Cusecs and the same has been assumed for the Weir.

Method of Disposal:—The flood will pass over the uncontrolled crest and no regulation is provided. A solid crest without gates naturally will create higher afflux, but it is not necessary to lower the afflux as no property will be affected.

Foundation:—Drilling was done at this site and the fresh Rock level is +860. The Rock is sound and free from fissures.

General Features and arrangements of the Weir:—The Weir (with crest at +902) is a solid gravity section with ogee crest and a 25′ Radius Bucket for deflection of flow. It is 1080′ long between faces of abutments and carries a road bridge of 12′ Roadway (designed for A class loading) over 7′-6″ wide piers spaced at 60′ centres. The abutments and wings provide the connection between the Afflux bundh and the Weir. A Regulator of 2 spans of 40′ is located in the Left Afflux Bundh and the Regulator and Weir are separated by natural hillock of massive rock.

Principal Levels and Particulars:—

(1)	Present HFL at site for 1927 flood ...	+905
(2)	Lowest Level of Weir foundation ...	+865
(3)	Crest Level of Weir	+902
(4)	Length of Weir between Abutments	1080′
(5)	Length of the natural River Channel	1100′
(6)	Maximum flood level uptsream after construction	+930
(7)	Maximum flood level downstream after construction of Dam at Noapara	+900
(8)	Road Level	+936
(9)	Radius of the Bucket	25′

Profile of the Section:—The upstream face is vertical and the downstream face is given a slope of .7 to 1. The rear batter of .7 to 1 and front face when produced meet at +937 i.e. 7ft. above the high flood level in the upstream after construction.

Profile of the spillway crest and length required to dispose of 5,00,000 Cusecs flood.

There are 18 spans of Bridge over the Weir and each clear span is 52.5′.

Total Opening	18×52.5	=945′
For a height of 28′ over crest end contraction	$18 \times 2 \times 0.04 \times 28$	=Say 42′
Net effective length		=903′

Maximum Discharge with 28′ head, with formula: $CLH^3/_2$ (when C=3.7 and L=Effective length)$=3.7 \times 903' \times 28^3/_2 = 5,00,000$ cusecs.

Thus the waterway is enough for a flood of 5,00,000 cusecs. The crest is given a curve to confirm to the formula $X^2 = 64.85Y$. The Bucket of 25′ radius is tangential to the bed line.

Nature of masonry proposed:—The entire Weir will be constructed of random rubble granite stone masonry with 1:4 red cement mortar. The upstream face will be pointed with 1:2 cement mortar as work progresses.

The downstream Spillway face will have a dressed stone facing with joints pointed with 1:2 cement mortar. The Bucket will be made of 1:3:6 cement concrete.

Measures to Prevent uplift:—Grouting will be done wherever required.

Approach Road & Afflux Bundh:—A Revetted earth bundh with 25′ top width and slopes of 1:2 in the upstream and 1:3 in the downstream will be provided. A metalled Roadway (to be subsequently tarred) will be provided over the bundh in continuation of the road over the Weir.

Head Regulator:—The capacity of the Power Canal is 4000 cusecs, and FSL at head is +900. The Regulator is designed to pass this discharge with pond level at +900.50. Two Spans of 40′ are provided. The vents are controlled by vertical lift shutters $40' \times 13.85'$. A Road Bridge of 12′ Roadway is provided in the rear. The Foundation at this place is likely to be disintegrated rock. The entire Regulator will be in cutting.

Calculations for required Waterway.

Working head =0.5

$V = \sqrt{2gh} = 8 \times .7 = 5.6$

Area $=80 \times 13.85$ =1108 sft.

Co-efficient assumed =.66

$Q = 1108 \times 5.6 \times .66 = 4136$ cusecs.

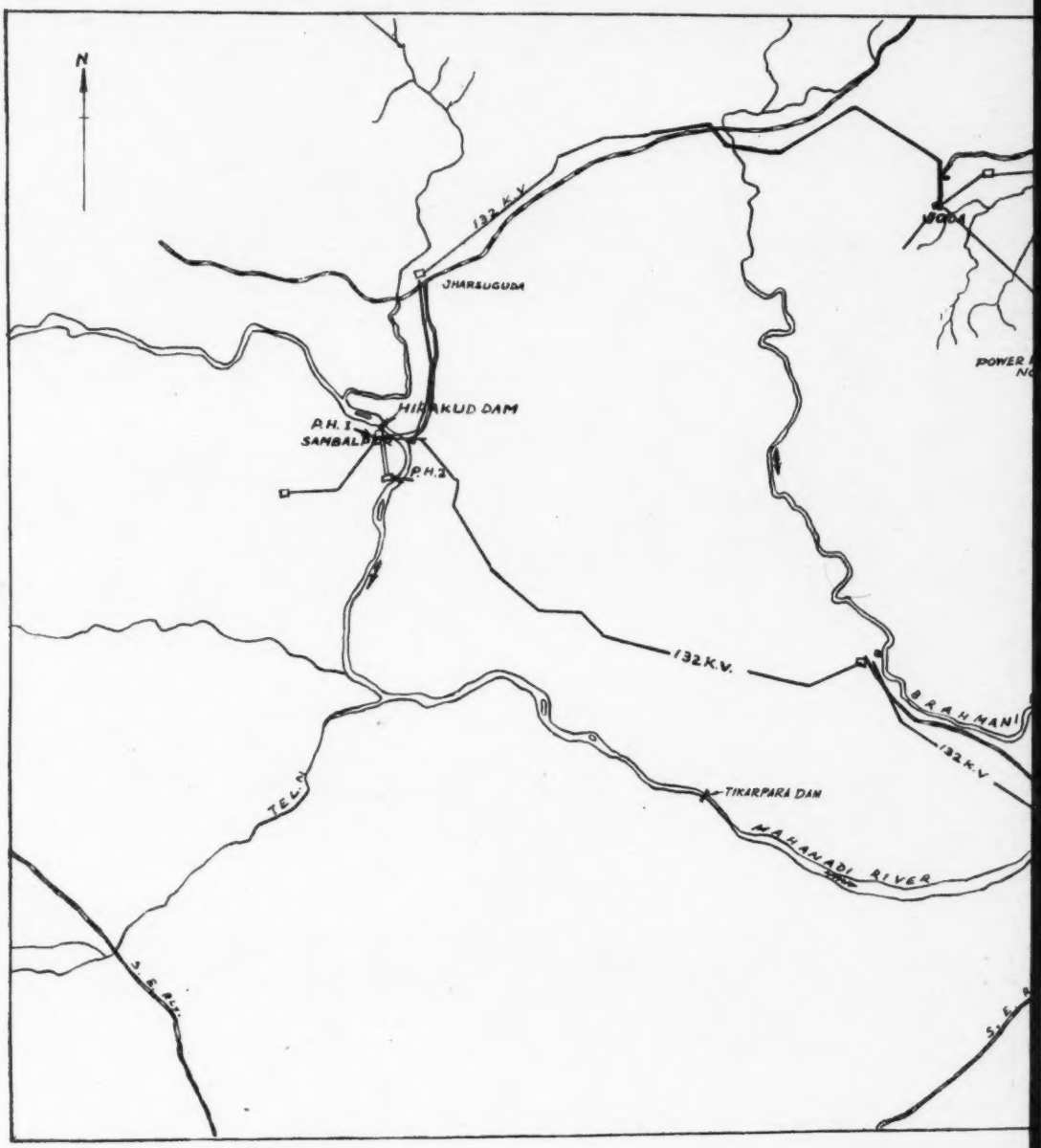


Plate I: Bhimkund Project showing T

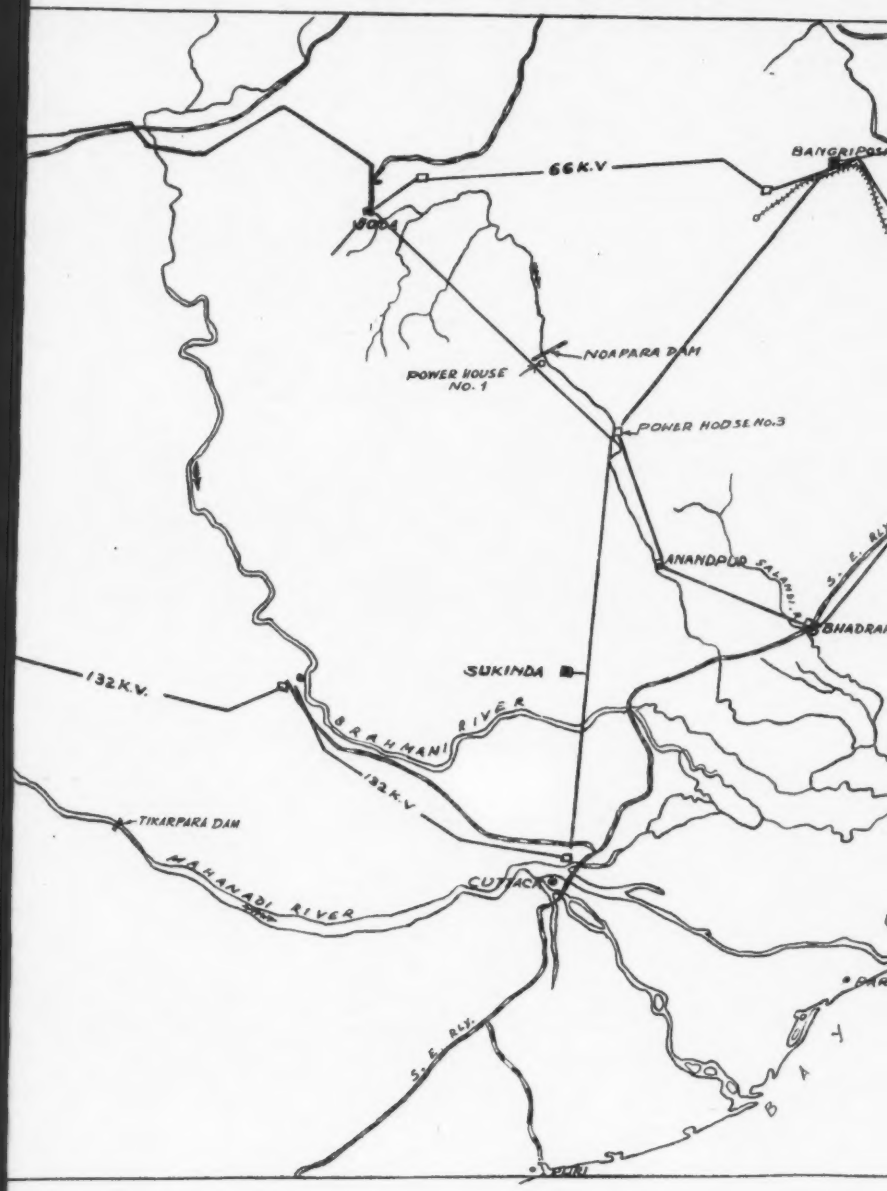
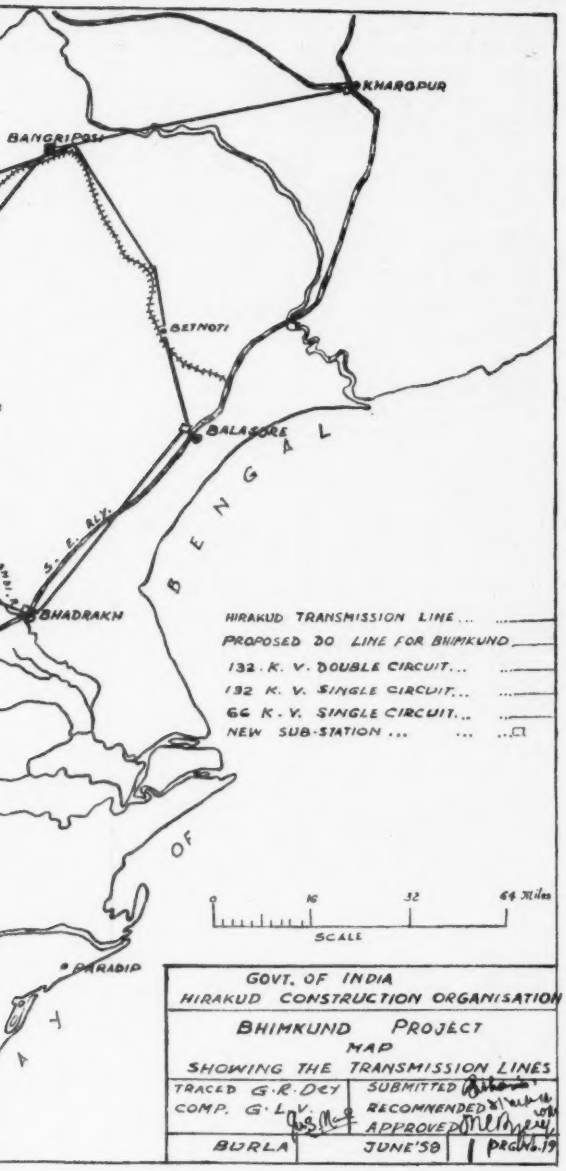


Plate 1: Bhimkund Project showing Transmission Lines



HIRAKUD TRANSMISSION LINE ... .
PROPOSED DO LINE FOR BHIMKUND .....
132. K. V. DOUBLE CIRCUIT... .....
132 K. V. SINGLE CIRCUIT... .....
66 K. V. SINGLE CIRCUIT... .....
NEW SUB-STATION ... .□

0 16 32 64 Miles
SCALE

GOVT. OF INDIA
HIRAKUD CONSTRUCTION ORGANISATION

BHIMKUND PROJECT
MAP
SHOWING THE TRANSMISSION LINES

TRACED G.R.DEY	SUBMITTED
COMP. G.L.V.	RECOMMENDED
	APPROVED
BURLA	JUNE'58

DRG.No. 19

B. POWER CANAL

Alignment:—The Canal will take off from the head Regulator at RD.0 of the Canal and will run for 5000′ parallel to the River upto Bhimkund Falls and from there it will take a turn and go upto where Dalkisahi Dam Axis crosses Kantamuli Nala. Here the alignment will go through a cutting and the maximum depth of cutting will be 70′. Beyond Kantamuli River crossing the alignment will run upto Tail (RD 45) without much detour. This will be the reach where pondage will be provided and the Canal will have a single bank for the entire length.

At Baigundi the Forebay is created by Canal bank and another bundh running from Baigundi to hill opposite Bajalpur. From a masonry Forebay wall located on this hill top, the water will be led by Penstocks to the Power Plant located in the River bed.

Capacity:—The Maximum discharge from upper Power Plants will be 3300 cusecs. There is an uncontrolled intervening catchment of 200 sq. miles between Dam and Diversion Weir and a flow of 550 cusecs will be available from July to September. The flow of 550 Cusecs will give about 40,000 KW. at 100% LF and this secondly energy of 8 million KWhrs, could be generated and sold. It would be desirable to provide for this extra discharge. It is, therefore, proposed to design the canal for 4000 cusecs.

Dimensions of the Canal:—Various sections were worked out on the basis of sum of cost of Power lost and annual cost. A bed width of 35′ and FSD of 15′ with concrete lining and a slope of 1 : 7000 works out cheapest. The velocity is 5.6 ft/sec.

Standards for filling:—The filling reaches will have the same specifications as for Dykes in the main Dam. Free board provided is 5′ above M.W.L.

Standards for cutting:—Cuttings will have a slope of 1½ to 1 from bed to top. Upto 3′ above FSD 6″ concrete lining 1:3:6 mix will be done and at this level a 10′ berm is provided. Another 5′ berm is provided midway and the cutting face will be protected by Turfing and suitable drains will be provided as is proposed for Dykes in the Rear.

Cross Drainage Structures:—The Canal will cross two major drains, Sim and Kantamuli with 50 and 30 sq. miles catchment respectively. It is proposed to cross them by Aqueducts and provide 15 and 12 spans of 25′ each. The Canal will go through 4 vents of 11′ each. The depth of flow in the Aqueduct will be 15′ and a free board of 2′ is provided above the FSD. The vent on the extreme right will carry a 10′ wide Roadway on the top.

All other small drains will be let into the Canal and an escape is provided to take care of the flood inflow. The total intercepted catchment is about 2000 acres.

Escape:—An Escape will be provided to discharge 10,000 cusecs with the rise of M.W.L. by 1′ above F.S.L. This Escape will be of automatic type. In addition sluices will be provided to discharge bed load and silt at times. The Escape is located at RD 22.5 where the Canal enters the pond area.

Bridges:—A Bridge is located at RD 28 opposite village Puranapani. Here the Canal is taken in 20′ cutting to provide for a Bridge location. In addition to this, another bridge will be provided over Head Regulator.

C. FOREBAY

Pondage available:—The Forebay has a pond area of 420 acres at F.S.L. (+897). The single bank of canal runs close to the 897 contour on the uphill side and if earth is borrowed between the levels of 897 and 892 additional pond area will be available. Even neglecting this, the pond area of 420 acres will give 2100 acre feet for 5 ft. variation. The average flow per day will be 6600 acre feet and thus 8 hours pondage will be availabe in the Forebay.

Forebay Wall:—As will be discussed later, this power station will have 7 units of 55 MW. each or even 8. Assuming 40′ as spacing of Units, and an independent Penstock for each, a total length of 400′ would be required for the Forebay Wall. The approximate foundation level has been assumed as +860.

Principal Levels.

FSL of Forebay	...	...	+897
MWL of Forebay	...	...	+898
Theoretical bed	...	...	+883
Top of Penstock	...	...	+878
Dia. of Penstock	...	...	108″ or 9′
Invert of Penstock	...	...	+869
Foundation Level of Forebay Wall	...	...	+860
Crest of Forebay Wall With 6′ free board above MWL	...	...	+904

Nature of Masonry proposed and profile:—This will be constructed of R.R. masonry (1:4 mortar) hearting and coursed rubble dressed stone facing with joints pointed with 1:2 cement mortar.

D. PENSTOCKS

Alignment:—The hill slope is covered with loose boulders and this has to be removed as far as possible. The total length of Penstock is 1850 ft.

Permissible velocity:—The maximum permissible velocity from operation point of view is 20′. A velocity of 18.7′ has been taken as the maximum permissible velocity for calculating size of Penstock.

Size:—It is proposed to provide an independent Penstock for each machine of 55 MW. Gross head is 667′ and after assuming 20′ losses the nett head is 647 ft. The maximum discharge to give 55 MW. at

$$\text{at 647 Head} = \frac{\text{Power} \times 14}{\text{Head}} = \frac{55000 \times 14}{647} = 1190 \text{ Cusecs}$$

$$\text{Assuming a dia. of } 9', V = \frac{1190 \times 4}{\pi \times 9 \times 9} = 18.7 \text{ft/sec}$$

Loss of head:—Loss of head for Penstock works out to 17 ft.

Thickness of Penstock:—Thickness of Penstock has been calculated by the formula $t = \frac{2.6 \times h \times d}{S \times E}$

Where t = thickness in inches.
h = 150% of static head taking 50% extra towards water hammer.
S = Stress = 13,500 lbs./sq. inch.
E = Joint efficiency = 90%.

An extra 1/16″ has been added towards corrosion. Minimum thickness provided is $\frac{3}{8}$″.

Anchors and Saddles:—Anchors will be provided at all bends and saddles are proposed every 20′.

E. POWER HOUSE AND PLANT

Maximum power output at the Main Power House for maximum Head and Maximum Discharge.

Maximum power output at 100% LF

$$= \frac{3300 \times 647}{14} = 1,52,500 \text{KW.}$$

Power output at 60% LF = 2,54,000 KW.

Installed Capacity:—It is proposed to install 5 units of 55 MW., and one extra machine of 55 MW. thus total installed capacity proposed is 330000 kW.

Spacing of Units and dimensions of Power House:—The spacing of Units will be 40′ and width will be 36′. For 6 machines length required is 240′ and adding 75′ extra for repair bay, overall length may be 315′ and width has been assumed as 40′.

Excavation required for draft tube:—A depth of 25′ below Tail Water has been assumed.

Materials:

Plenty of good granite will be available close to Work. Sand can be got from Sim and Kantamuli and from the River bed. Aggregate for concrete work will have to be rushed as natural river shingle is not available. Earth for formations in filling will be available along the alignment of Power Canal.

Transportation & Communication:

All weather communication is provided from Rail head upto Colony at Dam site. From Dam site a road leads to Dhenkikote. From this road a road will be branched off at village Dianari and this road will be continued upto Balijori and cross the River by a Bridge over Weir at Balijori and from there will be continued on the top of Right bank Canal. The existing road from Karanjia to Thakurmunda leading to Bhimkund Falls will be utilised after improvement.

Location of Camp:

A Bungalow and some temporary quarters are already existing at Balijori and these will serve the need during construction of Weir at Balijori. The permanent Colony will be located at village Baigundi where Power House maintenance staff will be ultimately housed.

Supply of Power during Construction:

A 11 kV. line will be extended from Dam site to Weir site, Baigundi Colony and the Main Power House. Approximate Power requirement may be 500 kW.

Q-Special T. & P.:

A provision of Rs. 50,00,000 is made for all works under Unit III.

ESTIMATES

A—Preliminary:

A sum of Rs. 40,000 has been provided for survey and alignment of Power Canal, and Masonry structures.

B—Land:

A sum of Rs. 5.40 lacs is provided to cover the cost of land at Rs. 500/- per acre and 15% for Solatium and 5% for L.A. Establishment.

C—Works:

Provision under this head covers the cost of Diversion Weir, Power Canal, Forebay Walls, Penstocks, Head Gates and Power House. Estimates are based on details except Power House which is estimated at Rs. 80/- per KW. of installed capacity.

F—Cross Drainage:

Cross Drainage works have been estimated on the basis of comparable structures in Hirakud Project and 15% extra has been provided for enhanced price of steel & cement. Total provision is Rs. 41.00 lacs.

G—Bridges:

Rs. 51,000/- has been provided for a bridge based on detailed estimate. Cost of Bridge on Regulator is included in C-Works. One Bridge is sufficient.

H—Escapes:

A provision of Rs. 8,00,000 is made for a Syphon Spillway for 10,000 cusecs.

K—Buildings:

Permanent Buildings are provided for maintenance staff and 100 temporary H-type are provided for (work-charged) staff. Primary School, Hospital, Store and Workshop buildings are also provided.

Total provision is Rs. 9.53 lacs.

L—Earth Work:

Earth work has been estimated at a flat rate of Rs. 80/- per 1000 cft. including all soils and all lifts and leads. This rate is quite reasonable and specially when most of the work is proposed to be done by Machines the rate will be adequate. Lining, Rock fill, Rip-rap etc. are provided for on the basis of analysed rates. Total provision under L-Earth Work is Rs. 211.89 lacs. The entire estimate is based on details except item L6 for which Rs. 15.00 lacs is provided as L.S. item for necessary protection works to deep cuttings which cannot be exactly foreseen at this stage.

M—Plantation:

A provision of Rs. 50,000/- is made for lawns and plantations for the Colony.

O—Miscellaneous:

A provision of Rs. 7.62 lacs is made for water and power supply during construction, telephone & wireless equipments, conservancy and amenities to Labour.

P—Maintenance:

1% of estimated cost is provided. Total provision is Rs. 8.00 lacs.

R—Communication:

A sum of Rs. 24.5 lacs is made for necessary Roads to the Main Power House.

Electrical:

Cost of Machines are estimated at Rs. 300/- per kW. Total provision is Rs. 9.9 crores.

TRANSMISSION SYSTEM IN STAGE—I

(1) *Transmission lines:*

The Transmission system is shown in Plate—I The following lines are proposed in Stage—I

132 kV. lines—Double Circuit

1. Main Power House to Joda ... 66 miles
2. Main Power House to Kharagpur ... 125 miles
3. Main Power House to Noapara Power House ... ... 26 miles

132 kV. lines—Single Circuit

Main Power House to Chowdwar ... 88 miles

66 kV. lines

1. Main Power House to Betnoti via Anandpur, Bhadrak & Balasore ... ... 110 miles
2. Link at Bangirposi ... ... 10 miles
3. A short line from Chowdwar line to Sukinda.

(2) *Sub-Stations:*

New Sub-Stations are proposed at the following places:

1. Kharagpur
2. Bangirposi
3. Sukinda
4. Anandpur
5. Bhadrak
6. Balasore

(3) *Extension to existing stations of Hirakud Grid:*

In addition to the above new stations, necessary extra equipment will be added in Chowdwar and Joda and Betnoti, the Sub-Stations of Hirakud Grid.

COLONY BUILDINGS

Buildings are provided at all new Sub-Stations and the Divisional Head Quarters is proposed at Bangirposi. In addition small colonies for transmission line maintenance are provided.

TRANSPORT AND COMMUNICATIONS

The lines are proposed to follow existing roads within a distance of about 3 miles. The materials required can be received at Rail heads which are available at all proposed Sub-Stations expect at Anandpur and Sukinda for which Jajpur Road Station will be the Rail head.

Q—SPECIAL T. & P.

Provision of Rs. 50,00,000 for Unit III includes provision for this also.

ESTIMATES

A—Preliminary:

A provision of Rs. 4.21 lacs is made to cover the cost of Survey and alignment for 421 miles of Transmission Line. Rate provided is Rs. 1000/- per mile.

B—Land:

Rs. 45,000/- is provided for cost of land for Sub-Station Building sites.

C—Works:

This Sub-head covers the cost of Transmission Lines, Telephone Lines and Sub-Station equipment.

Rates adopted are as given below:

132 kV. Double Circuit	Rs.	85,000/- per mile
132 kV. Single Circuit	Rs.	55,000/- per mile
66 kV. ...	Rs.	31,000/- per mile
Telephone Lines ...	Rs.	5,000/- per mile

Sub-Station equipment is estimated on the basis of current prices.

Total provision is Rs. 399.45 lacs.

K—Buildings:

A sum of Rs. 25.00 lacs is provided for Buildings.

O—Miscellaneous:

5% on items A-Preliminary, C-Works, K-Buildings is provided to meet the cost of items like Conservancy, Inspection vehicle, Anti-malaria operation etc.

Noapara Dam

by S. C. TRIPATHI

THE site selected for the Dam was surveyed by detailed block levelling on the ridge for a width of 1000′. The alignment was marked over the most economical alignment. Capacity survey by air photography is yet to be done. For the present, capacity has been worked out from 1″ maps.

SUBMERSION

1180 is proposed as the F.R.L. and M.W.L. At this Level the submersion will be 80,000 acres or 125 sq. miles. All the area that will be submerged by the Reservoir will be inside Orissa State. A portion of National Highway No. 6 between Karanjia and Keonjhar will be affected and the same is proposed to be diverted over the Dam. The extra detour will be 2 miles. The Reservoir will not submerge any known valuable mineral deposits.

The average density of population of the area is 350 per sq. mile and a total of 50,000 people may be displaced. Taking average 5 persons in a family, it may be presumed that 10,000 families will be displaced. Total agricultural land affected may be about 32,000 acres.

The people can be resettled in Thakurmunda area of Mayurbhanj District and Harichandanpur area of Keonjhar District where the population density is 50 per sq. mile. In addition some can be settled in marginal lands above the Reservoir.

The people mostly affected are the Adivasis (abori gines) who came and reclaimed the forests and settled down within the last 40 years. They are very hard working and will settle themselves with minimum assistance. However, as they have reclaimed the land with their own hands, they naturally will have sentimental attachment for their land but that can not be helped as some will have to undergo sacrifices for the good of a large number.

EVAPORATION LOSSES IN NOAPARA RESERVOIR

The following data has been assumed.

January	...	...	...	3.6″
February	...	...	...	2.9″
March	...	...	...	5.5″
April	...	...	...	6″
May	...	...	...	9.2″
June	...	...	...	8″
July	...	...	...	8.6″
August	...	...	...	8.4″
September	...	...	...	9.00″
October	...	...	...	5.00″
November	...	...	...	3.30″
December	...	...	...	2.50″
			Total:	72″

Total evaporation assumed for Hirakud is 72″ and for proposed Salandi Reservoir it is 48″. The actual evaporation may be somewhat less.

STORAGE CAPACITY REQUIRED FOR POWER GENERATION

A study of storage requirement was made from mass curve. The inflow during non-monsoon period (2 lacs acre feet) was assumed to compensate for evaporation and cumulative run off (after deducting 2 lacs acre feet) was drawn from 1949 to 1956 (the worst period during last 52 years. A study of the graph shows that the stream can yield a maximum regulated discharge of 3600 cusecs and the maximum storage capacity required is 3.3 million acre feet (Live capacity). Adding 4 lacs acre feet for silt, the gross capacity required is 3.7 million acre feet. This would require F.R.L. of 1184. Between 1184 and 1180 (capacity 3.4 million acre feet gross and 3 million acre feet live) it was seen that the difference in Power out-put would be 12000 kW. and cost difference Rs. 3 crores.

The interest and working expenses on Rs. 3 crores would be Rs. 21 lacs (5% interest and 2% working expenses) and the value of Power lost at Rs. 164 per kW. year would be Rs. 19.68 lacs and at Rs 200/- per kW. year, it would be Rs. 24 lacs.

Thus raising of the Reservoir from 1180 to 1184 would not make power generation any cheaper. It is, therefore, proposed to limit the F.R.L. to +1180 as the cost of generation is slightly less at this F.R.L. A Reservoir level of 1175 to 1170 could be considered but the power need is there and it would not be advisable to restrict the scope especially when no other suitable site is available for providing storage at a later date.

A working table has been prepared in the usual manner and it is seen that a capacity of 3.4 million acre feet would give 2,20,000kW. of Power at 100% LF and during the two worst dry years (excluding 1947 and 48) there would have been no power cut.

It is, therefore, proposed to provide a live capacity of 3 million acre feet for power generation (gross capacity 3.4).

Noapara Dam site from Right Bank Upstream

FLOOD CONTROL ABILITY OF THE PROPOSED RESERVOIR

As will be seen from working table generally the level of Reservoir will be at +1160 in the 1st week of August when floods occur. A capacity of one million acre feet will be available for flood moderation in the 1st week of August. One million acre feet expressed in inches run off over the catchment above Akhuapada is equal to 5″ run off. The maximum flood occcured in 1927 when it is estimated, the run off at Akhuapada was 10″ to 11″. The average rainfall over the catchment was only 13″ and run off could not have been more. It is estimated that the flood peak was 5,00,000 cusecs (Orissa Flood Committee report). Even assuming 11″ as run off during 1927 flood, the run off (due to flood absorption) would have been 6″, and the peak would have been $5{,}00{,}000 \times {}^{6}/_{11} = 2{,}80{,}000$ cusecs. This is a substantial reduction in flood peak. Theoretically the downstream catchment of 1700 sq. miles can give a flood of 2,80,000 cusecs or even more. A small catchment like that of Salandi with 240 sq. miles catchment gave a flood of 1,50,000 cuecs in 1941. It is, therefore, unnecessary to raise the Reservoir F.R.L. for flood control purposes. In most years however the flood is due to catchment above Dam site and the Reservoir will substantially control the flood. In fact, except the 1941 flood, all other major floods were due to catchment above Dam.

WHETHER THE RESERVOIR WILL MEET IRRIGATION REQUIREMENT AND OTHER NEEDS

Total land available for irrigation is about 5 lacs acres even including the Salandi Project Ayacut. A maximum discharge of 5,000 cusecs is required for Khariff irrigation and a maximum of 2,500 cusecs is required for Rabi irrigation (Assumed intensity 150%).

The minimum monsoon flow from downstream catchment of 1700 sq. miles is 3,400 cusecs and adding Power release the minimum monsoon flow comes to 6,600 cusecs. During Rabi season the minimum flow is 3,200 cusecs whereas requirement is about 2,500 cusecs.

Thus the capacity of 3.4 million acre feet while utilising the water resources to the maximum for purposes of Power generation, will be able to control the flood and irrigate all the land available and yet provide a surplus for navigation, prevention of pollution of river and drinking water supply for villages and towns.

A Reservoir of 3.4 million acre feet capacity is finally proposed. The F.R.L. required for this capacity is +1180.

SILTING OF NOAPARA RESERVOIR

Silt observations have been done for one year only.

This happened to be a drought year and it is not possible to estimate with great accuracy the quantities of silt that will be deposited.

During the period June to September, 1957, for a total flow of 1.6 million acre feet the silt charge was as follows:—

Coarse silt	50 acre feet.
Medium silt	70 acre feet.
Fine silt	1470 acre feet.
	1590 Say 1600 acre feet.

Fine silt is practically 90% of total silt charge.

For an average inflow of 4 million acre feet the total annual silt charge would be $\frac{1600 \times 4 \text{ m.a.ft.}}{1.6 \text{ m.a.ft.}}$

= 4000 acre feet.

Some silt will naturally escape during non-storage period but even assuming 100% as retained, the capacity required for silt Reserve to last 100 years is 0.4 million acre feet. For this Reservoir 0.4 million acre feet is provided as silt Reserve.

The catchment basin at present contributes a large amount of Sediment on account of shifting cultivation by Adivasis on hill tops and slopes.

For the last few years, the State Government have been trying to resettle them in plain lands and situation is likely to improve soon.

This is a Project where returns are handsome and expenditure on soil conservation can be met out of Project Funds. Besides, the area where soil conservation measures are needed, is 1000 sq. miles and it is practical to conserve the soil in a limited area. A provision of Rs. 15,00,000 is also being made for soil conservation.

Life of this Reservoir is very long. Even after six hundred years it will have enough capacity to generate at least 2,20,000 kW. at 60% LF.

MAXIMUM FLOOD DISCHARGE

There are no clear flood marks to compute the maximum flood. Local enquiry was made at Dam site and the HFL for 1927 flood is assumed as +1068 at Dam site.

For Kutter's n = .05 and slope of 1.43 per 1000 the Maximum Discharge works out to 7,30,000 Cusecs. Formula $C\sqrt{M}$ gives 4,86,000 Cusecs for value of C = 10,000. Envelope Curve for North Indian Rivers would give maximum discharge as 5,00,000 Cusecs (approximately). Hence 5,00,000 cusecs is taken as maximum peak flow.

METHOD OF DISPOSAL OF FLOOD

The flood has to be discharged at the River and the spillway has been located in the River portion. The storage capacity and consumption is large and no surplusing can be done before filling. Sluices are therefore unnecessary in this case. It is proposed to install Crest gates of 40′ × 40′ size for flood disposal.

LOCATION OF NOAPARA DAM

The Dam will be located upstream of village Noapara, a small village on the Right bank. The Dam will close the valley by joining Dharam Dwari-Hills on the Left and Holari Huri on the Right. The Axis crosses the River at Lat. 21°-40′ North and Long. 80°-52′-30″ East.

The deep Course of the River within banks is about 850′ and is sufficient to locate the spillway. Though the gap to be closed is 36500′ the total length of Dam in excess of 100′ height will be only about 8000′. The bed lower down is rocky and retrogression downstream is not expected. The base for the earth Dam and Dykes is free from gullies due to erosion.

The entire Dam will rest on sound foundations and normal construction methods will ensure a safe and sound structure.

FOUNDATIONS

The foundations in the river bed have been explored by drill holes. The Rock is closely jointed granite and is not expected to have any fissures and only nominal grouting will be necessary.

Test pits were put-in to find the depth of cut off for Earth Dam. It is seen that cut off depth will not generally exceed twenty feet and cut off can be taken to impervious strata.

Sri Ramachandran, Assistant Geologist, Geological Survey of India, has visited the Dam sites. His report says that "the Baljori site appears to be quite suitable geologically for the proposed composite dam with a concrete or masonry overflow section in the river bed and an earthen dam on the banks".

The deepest foundation Level in the River bed will be +1000 and the maximum height of structure will be only 192′ and the maximum depth of water retained will be 180′ above the deepest foundation.

GENERAL FEATURE AND ARRANGEMENTS OF DAM

These are shown in the drawings of general plan Elevation and Typical Section.

The total length of the Dam will be 15000′ with Dykes (height less than 50′) extending 12500 ft. on Left bank and 9000′ ft. on Right bank. From the left to right the Dam will consist of the following Sections:

(i)	Left Earth Dam	R.D. 0 to 5400
(ii)	Left non-overflow Dam ((Masonry)	R.D. 5400 to 6600
(iii)	Spillway Dam (Masonry	R.D. 6600 to 7300

(iv) Right non-overflow Dam (Masonry) R.D. 7300 to 8850

(v) Right Earth Dam R.D. 8850 to 15000

The maximum height of Earth Dam will be about 110′ and that of Masonry Dam 192.

The Power House at the dam site will be of the out-door type and will be located on the right portion of the river channel at the toe of the non-overflow Dam. The Switch Yard will be adjacent to the Power House. A high coefficient overflow spillway with 14 radial crest gates, each 40 ft. high by 40 ft. long, will be situated above the natural river channel.

A rolled filld Earth Dam and Dyke will run beyond the non-overflow section on either flanks and abut against hill slope. The front and rear slopes proposed are 3 to 1 and 2 to 1 respectively. Suitable berms, filter blankets and rock toe will be provided. The cut off trench will be taken to impervious strata.

The Dykes (height less than 50′) will be similar to Earth Dam sections but with lesser protection works. Besides the Earth Dam will have zoning whereas Dykes will have a homogeneous section.

On the top of the Dam is proposed a 22′ wide roadway which serve as a National Highway connecting the Keonjhar District with Mayurbhanj District. Within the Dam, inspection gallery extending the full length of the masonry Dam will provide for interior drainage, space for deep curtain grouting and access to panels recording the readings of the various instruments to be installed in the masonry portion of the Dam.

The trash rack structure will be reinforced cement concrete semi-circular towers. Two 20′ diameter penstocks of 1″ thick welded steel plates will be embedded in the body of the Dam in Block 21 and 22. The penstocks will be connected to welded steel scroll cases.

Two Bed sluices of 8′ × 10′ are proposed to be located in Block 20.

PRINCIPAL LEVELS AND PARTICULARS

Average bed level of river at Dam site	+1020
Anticipated lowest level of Dam foundation	+1000
Crest level of spillway section	+1140
Full Reservoir Level	+1180
Maximum Reservoir Level	+1180
Proposed Minimum Reservoir Level	+1115 to +1120
Level of roadway over Dam	+1192
Level of top of parapet	+1195
Maximum tail water elevation	+1055
Sill of construction sluices (2 nos. 10′ × 8′)	+1020
Invert level of upturned bucket	+1005
Total length spillway including piers	716′
Total length of masonry non-overflow section	2834′
Total length of Earth Dam	11450′
Total length of Dykes	21500′
Total length of Dam including Dykes	36500′
Width of roadway on top of Earth Dam	25′
Width of roadway on top of spillway	22′
Number & size of radial crest gates 14 Nos 40′ × 40′	
Number & size of construction sluices 2 Nos. 8′ × 10′	
Height upto road level of Dam above deepest foundation	192′
Flood discharge provided	5,00,000 Cusecs
Area of water spread at +1180	80,000 Acres
Capacity of Reservoir at +1180	3.4 M.A. ft.
Live storage	3.0 M.A. ft.

DESIGN OF NON-OVERFLOW SECTION—PROFILE OF DAM

For working out the stability the specific gravity of Masonry has been assumed as 2.35. Uplift has been assumed to vary from full hydrostatic head at the upstream to full hydrostatic head due to tail water at +1055 and act over $\frac{2}{3}$ of the area. For this Reservoir, M.W.L. is same as F.R.L. and +1180 has been assumed for stability computation.

Computed maximum stresses are given below:— (at foundation level of Maximum section).

Reservior empty.

Non-overflow section	184.3 lbs/sq. inch.
Spillway section	148.9 lbs/sq. inch.

Reservoir Full

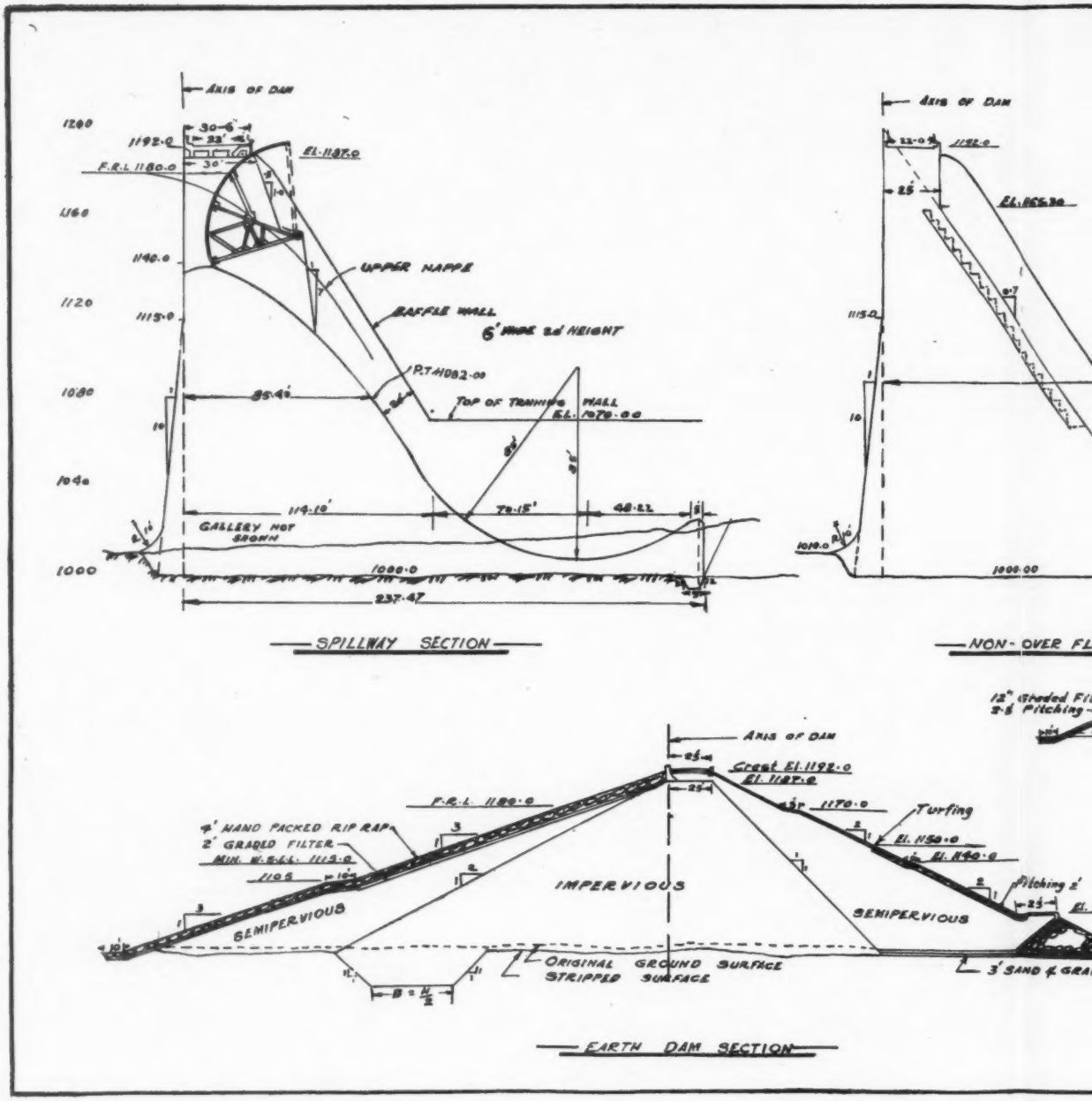
Non-overflow section	130.1 lbs/sq. inch.
Spillway section	122.5 lbs/sq. inch.

The masonry is thus subjected to a maximum stress of 184.3 lbs/sq. inch i.e. 11.9 tons per sq. foot. The mortar proposed for the masonry is 1:4 (1Surki, 4 Cement).

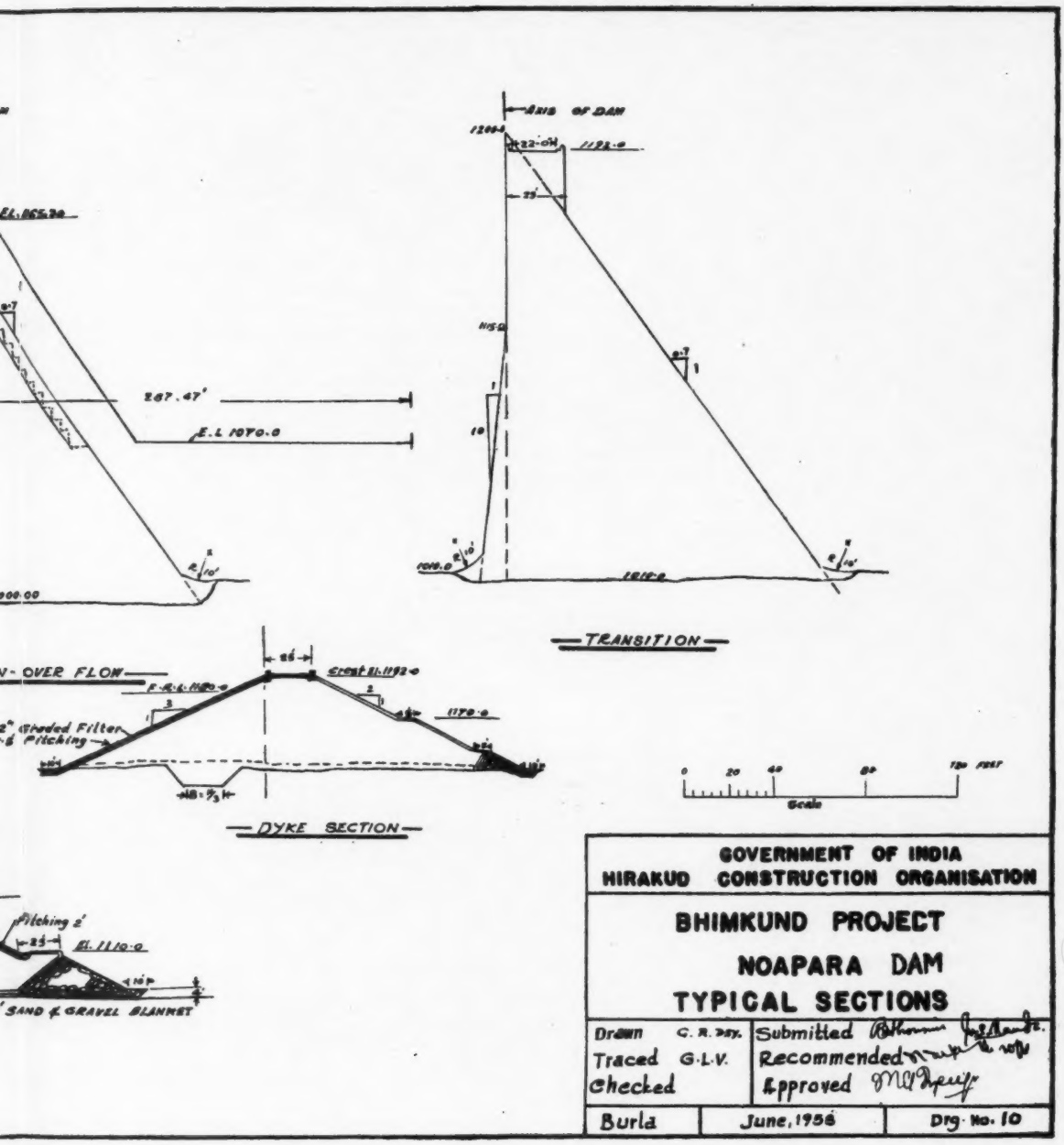
SPILLWAY SECTION

The spillway is of solid gravity type with the crest and downstream face curved to conform to flow of water. Clear waterway provided is 14 spans of 40′ and including 12′ thick piers; the overall length of spillway is 716′. The crest level is +1140 and M.W.L. is +1180.

There will be 28 end contractions:



Noapara Dam—Typical Sect



-Typical Sections

Total reduction in length due to end contractions. ... $=28 \times .04 \times 40' = 44.8$ Say 45'

Effective length of Spillway ... $=560 - 45 = 515'$

Maximum Discharge capacity of spillway with value of C=3.98 in the formula $CLH^{3}/_{2}$ ... $=3.98 \times 515 \times 40^{3}/_{2}$

... ... $=5,18,000$ Cusecs.

Discharge capacity of spillway with Reservoir at 1160. value of C=3.615 fraction of designed head=.5 $=3.5 \times 520 \times 20^{3}/_{2}$

$=1,66,000$ Cusecs.

Thus the spillway will pass the maximum flood even if such a flood comes when the Reservoir is full. The Reservoir will normally remain at +1160 in the beginning of flood season and if flood warnings indicate heavy rainfall, the spillway will be able to discharge 1,66,000 Cusecs even before the flood inflow. Thus the spillway arrangement by crest gates is satisfactory.

The Profile :—The Crest has been designed as per Creager's equation.

Bucket :—A 85' radius upturned Bucket has been provided for deflecting the flow.

Piers :—12' thick piers are provided.

River Wall :—Training walls have been provided upto +1070 i.e. 65' above Bucket level.

Spillway Gates:—40' × 40' Radial gates are being manufactured by Tungahbadra Workshops for Kotah Barrage in Rajasthan and exactly similar gates have been proposed so that it may be cheap on account of its being a 'Repeat job'. Besides a square size is usually economical.

LOW LEVEL CONSTRUCTION SLUICES

Generally the River flow goes down by end of September and by first of October, the discharge is about 2000 Cusecs. Sometimes, due to winter rains, the discharge in February may go upto 2000 Cusecs. It is enough if the Construction Sluices are designed to pass 2000 Cusecs flow. Monsoon flow is large and has to pass over the incomplete spillway. 2 Sluices of 8' × 10' spaced 25' centre to centre have been proposed to be located in Block 20 with sill at +1020. They will not be located in the deepest bed as operation of the gates would be difficult in the spillway portion. A small screen wall will separate the flow from Power House. These sluices will also be used to release water for the Main Power House before the Dam is completed and so stoney gates are proposed for operation at a head of about 120'. The velocity will be quite high and the sluices are to be lined with concrete. Necessary bell mouth entry will be given to increase the coefficient of discharge.

Construction Joints :—In general vertical contraction joints 104' apart (except at the Power Dam where spacing of machines will determine the joints) have been adopted. No special construction joints are necessary as the construction is in masonry.

Each vertical joint will be provided with two 16 gauge copper sealing strips spaced 18" apart with 5" × 2½" vertical bituminous filling on both sides of the plates for allowing expansion or contraction.

Prevention of Uplift :—4 Rows of holes spaced 20' centres, 20' and 40' deep alternatively will be drilled and grouted from the gallery. The drainage gallery (6' × 7') running throughout the masonry Dam will relieve uplift. Necessary drainage pumps are being provided.

Installation of Instruments :—During construction, instruments necessary for the study of temperature, strains, contraction joint openings, deflections, hydraulic uplift etc., will be installed in the masonry Dam. Instruments for observation of settlement, pressures, etc., will also be installed in the Earth Dam.

Nature of Masonry Proposed and Face Finish :—The Dam is proposed to be built of rubble masonry in Red Cement mortar of 1:4 or 1:5 with Surki-cement of 1:4 proportion. The impervious facing on the upstream side will be built in richer mix 1:2¾ (Red cement mortar). It is proposed to have water tight joints by jointing with 1:2 Red Cement mortar as masonry progresses. The thickness for which richer mix will be provided would depend on head of water at the place. An average thickness of 10' may be sufficient. The downstream will be finished flush as work progresses.

The spillway section in the rear will have the same specification as the non-overflow sections. The downstream face and ogee curve will be made of specially dressed granite stones and pointed with 1:2 Red Cement mortar.

The Bucket and sill walls will be in concrete of 1:3:6 mix with 20% surki added to cement.

Architectural Finish:—Suitable architectural treatment will be given to the parapets and provision is also made for ornamental standards for lights over the dam.

EARTH DAM

The Earth Dam will be of "rolled filled" type with zoned sections. The maximum height of the Earth Dam will be 110'.

The Earth Dam will have a top width of 25'. The upstream slope is 3 to 1 with a 10' berm at Elevation 1105. The downstream slope is 2:1 with 5' berms at EL. 1170 and 1140. A 25' road at EL. 1110 on the downstream slope serves as an inspection road for the Earth Dam. The crest will be 25' wide and will be topped with 1" premix carpet.

A heavy rock toe will be provided on the downstream side for efficient drainage. The height of the

rock toe will be not less than one-fifth of the height of the Dam.

The upstream slope will be protected by hand placed rip-rap which will have a thickness of 4′ above EL. 1105, which is 10′ below the minimum draw down level. Below 1105 the thickness provided is 3 ft. as this zione will not be affected by waves.

Below the rip-rap there will be filter of 12″ thick gravel of graded size and 12″ thick coarse sand to effect efficient drainage without the soil particles getting dislodged as the water level in the Reservoir goes down.

The downstream slope will be protected from the erosive action of wind and rain by turfing upto EL. 1150 only. Below this elevation the slopes will be pitched 1.25 ft. thick as experience has shown that it is economical in the long run. Turfing involves large maintenance expenditure. In addition longitudinal and cross drains are provided to collect the rain water and lead it down to the bottom drain and then outside the Earth Dam, without damaging the earth slope.

The impervious zone will have a slope of 2 to 1 on the upstream and 1 to 1 on the downstream.

A three-layer filter Blanket will be provided, on the downstream side under the semi-pervious zone.

Cut off trench will be provided at the upstream edge of the impervious zone. The trench will have a base width equal to half the height of the Dam subject to a maximum of 50 ft. The trench will extend 5 ft. into compact sub-soil.

A single line of grout holes 30 ft. deep both primary and secondary will be drilled, washed and grouted to refusal to seal off any possible leakage past fissures and crevices in the bed rock where met with. The holes will be spaced 20 ft. apart. First primary holes will be drilled 40 ft. apart and grouted. The secondary holes will be drilled in between the primary holes and grouted. If the consumption of grout is heavy in certain zones, additional holes will have to be drilled and grouted.

Earth Dykes :

The main Earth Dam will be flanked on either side by Dykes. The Dyke will also be built to the same specifications as the Earth Dam except for certain reduction in the protective items. The section will be homogeneous i.e. no Zoning will be adopted. For typical section refer to figure.

Road Over Dam :

The Roadway over the Earth Dam and Dykes will be 25′ wide with parapets on the upstream side and 12″ sq. kerbs on the downstream side. The entire length of the road over Earth Dam and Dykes will be surfaced with 1″ premixed carpet. The Roadway over the spillway will be 22′ wide.

BUILDING MATERIALS

A. Stone :

Hard, dense, durable and sound granite rock is available almost all over the place. The dolerite dykes running across the river every half a mile could be made use of.

The dolerite dyke may be utilised for stones for rip-rap and rock toe.

The bed of the river itself will be an unlimited source of stone for all the works. The stones from excavation can be utilised for random rubble masonry.

B. River Shingle:

As the bed of the river is quite steep there is less scope for accumulation of shingle or sand. So shingle in appreciable quantities is not available. Broken stones will have to be used for filter blanket also but for the first two years' requirement, some shingle, available within 6 miles below and above the Dam, can be used.

C. Sand :

Due to the steep slope of the river bed there is no sand deposit within reasonable distance from Dam. Sand has to be brought from Deo Nadi mouth which is about 10 miles away. Economics of crushing stoness to obtain sand has to be looked into. If crushed stone sand is cheaper than the carriage of 10 miles, crushed sand may be used mixed with natural sand to get better workability for mortar. Crushed stone has to be used for graded filter also. Rate provided is sufficient for crushed sand also.

D. Cement :

The cement requirements can be met by the existing Factories at Jhink-Pani and Rajgangpur. The nearest Railway Station, Badampahar, is 35 miles from Dam site.

E. Pozzalona :

Soil suitable for surki is available. The admixture will reduce cost besides conferring other advantages.

F. Earth :

Test pits along the alignment and a number of test pits in the borrow area were done and samples were tested in Hirakud Research Station. The required quantity will be available within 3 miles lead.

COMMUNICATION AND TRANSPORT

The nearest Rail head is Badampahar, the terminus of Tata Nagar-Badampahar Line (a Broad Gauge route). From the Rail head of Joshipur and then to Karanjia there is the existing "National Highway No. 6" in good condition. From Karanjia a new road as a substitute for the National Highway No. 6, going

under Reservoir, will have to be built and this road will be connected to Dam site by a vented causeway below Dam. Total Road milage from Dam to Rail head will be 35 miles. At present there is no bridge over Deo Nadi and a bridge has been provided to make the Road an "All Weather" one. From Dam site to Dhenkikote there is an M.D.R. which is under construction and would be an all weather Road, by the time construction starts and communication to Jajpur Road on Calcutta-Madras route would be possible. The distance however is 67 miles and this rail head will be useful in case there is breakdown in Badampahar Route.

The section of S.E. Rly. from Kharagpur upto Tata Nagar is now a heavy traffic line and the Railways will have to make adequate arrangements to cope with the Project traffic for which they are being intimated now. Special sidings that will be necessary are also provided here.

Road Transport from Rail head has to be arranged by Diesel lorries and heavy trailers and the Project will own the transport system to make transport smooth and cheap.

CONSTRUCTION CAMP

A large area on the Left Bank just a mile downstream of the Dam and overlooking the River has been selected for the staff Colony and offices. The Workshop and Stores may be located just two furlongs downstream of the Dam on the Left side. Good amenities, protected and adequate water supply and drainage must be provided to ensure efficiency among the employees. The water supply scheme to supply 9 lakh gallons of potable water a day and equal quantity for construction purpose will have to be provided. The camp and quarters will be provided with electric lights and sanitary fittings. A fully equipped Hospital and a High School will be established at the Dam site Colony. Primary School and First Aid Centre and a Park will be provided in the Colony. The Park will separate the work site from the staff Colony. The area selected is above present flood level.

POWER FOR CONSTRUCTION

The Hydro-Power from Hirakud is available at Joda which is only about 40 miles from the Dam site. The Power Line from this Project will be ultimately connected to the Hirakud grid at Joda and Chowdwar. A L.T. line will have to be put in from Joda to Dam site, so that power can be drawn from Hirakud for the construction of this Project. About 2000 kW. may be the maximum requirement.

Q-SPECIAL TOOLS AND PLANT

About 30 crores c.ft. of Earth work in Dam and 20 crores c.ft. of Earth work in Power Canal will have to be executed by Earthmoving machines. Compressors are required for Rock Blasting. A workshop is proposed at the site of work. Besides, Cranes are required for Power Plant erection and supply of mortar and stone for the masonry Dam towards the end when masonry will be in progress in higher elevation.

A fleet of Trucks and Trailers are required for cement carriage and carriage of heavy penstock pipes, gates, Electrical machines etc.

A provision of Rs. 450 lacs has been made in the estimate. A sum of Rs. 200 lakhs will be debited to works and net Q-Special T & P. provided is Rs. 250 lacs. Rs. 200 lacs is proposed to be charged to Dam and Rs. 50 lacs to Power development. (Unit III).

ESTIMATES FOR UNIT I—DAM & RESERVOIR

Provisions contained in the various estimates for works are briefly described below:—

1 Works:

A—PRELIMINARY

This provides for investigations done so far, final Surveys, Hydrometeorological, silt and other observations proposed to be carried out during execution period, survey by Geological Survey of India and capacity survey by Aerial Photography, Model experiments have also been provided under this. Amount provided is Rs. 21.45 lacs.

B—LAND

A provision of Rs. 605 lacs under this head covers the cost of Land, Houses, Trees, wells etc., cost of transportation of people, cost of establishment for land acquisition and 15% towards solatium. Provision has been made for Reservoir clearance also. For 30,000 acres in the Balijori Reservoir the estimated cost was Rs. 2.27 crores and on this basis cost of 80,000 acres has been estimated at Rs. 605 lacs.

C.—WORKS

A provision of Rs. 1667.34 lacs under this includes cost of clearing site, diversion and care of stream during construction, cost of Earth Dam and Dykes and Masonry Dam, Transitions, overflow and non-overflow sections.

The Road over the Dam, illumination of Dam after construction, measuring instruments, and all gates and hoists for spillway operation and metal work for gallery, buckets, spillway bridge are included under this head. The entire estimate is based on details of quantities.

K—BUILDINGS

A provision of Rs. 121.25 lacs has been made on the basis of actual requirements as worked out in detail. Provision for Offices, Workshops and Stores, Schools, Hospitals, First Aid Centres, Rest Houses,

(Continued on page 51)

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Canal System

THE Barrage site is located at Birgobindpur. It will be a barrage on sand foundation and will be subjected to a head of 30′

Ramchandrapur Canal (Right flow Canal):—It will take off at the Right bank of Baitarani from barrage at Birgobindpur. The total length of the main canal will be 18.6 miles. It will irrigate an area of 73,287 acres on the down hill side between the canal and the river and High Level Canal Range II. The F.S.L. of Canal at the head will be +150 and after running an idle length of 6 miles it will start commanding. The discharge at head will be 900 Cusecs.

There will be six major distributaries and the biggest, Tarakot distributary will carry a discharge of 272 Cusecs at the head.

Anandpur Canal (Left flow Canal):—The canal will take off from the Barrage with F.S.L. +150 at head. Originally the Ayacut of this Canal was proposed to be irrigated by a Canal from Salandi Reservoir, but that was before the present scheme was thought of. Now it is proposed that the Salandi Project will extend irrigation towards Balasore District and the area between Right bank of Salandi River and Left of Baitarani, upto High Level Canal Range III will be commanded by Anandpur Canal. The Canal will carry a discharge of 1230 Cusecs at its head. The total length of the main Canal will be 16.8 miles. It will irrigate 1,05,000 acres C.C.A. through a net work of Distributaries and Minors.

There will be one Branch, Akhuapada Branch, offtaking at RD 59 of Main Canal.

CHARACTER OF THE TRACT COVERED BY IRRIGATION

The tract covered by irrigation is mainly rice growing. As ascertained during Salandi investigations 93% of the land is under Paddy and 5% is under Jute and the rest under Sugarcane. In some Thanas rice growing area is as much as 98%.

The lands are fertile and are fit for all types of tropical cultivation. Besides, the population density is about 450 per sq. mile and so the pressure on land and need for growing more crop is existing and what is needed is dependable water supply the crop period. But unfortunately this area suffers from droughts frequently.

On account of partial crop failures the ryots have become poorer. The average yield is hardly 11 to 12 maunds in a good year.

The average yield taking 16 annas as full yield is given below for different years.

By K. S. S. MURTHY

46-47	11 annas	49-50	8 annas
47-48	10 annas	50-51	8 annas
48-49	10 annas	51-52	11 annas

Rainfall:—The mean monsoon rainfall of 4 stations in the Ayacut is given below.

Station	No. of Years	Mean monsoon rainfall
Akhuapada	42	42.83″
Anandpur	34	40.02″
Bonth	22	46.55″
Korai	22	38.55″

Mean itself is insufficient for paddy which requires 60″. During the dry years the rainfall is less than this mean figure and so no further examination is necessary to prove that irrigation is needed in the area. At least in 50% of the years the crop failure is partial. This aspect has been fully examined in Salandi Project Report.

Existing Irrigation:—There is no major irrigation project in the proposed C.C.A. and some minor tanks irrigate nominal areas during Khariff. But these tanks have no value in a drought year. With the introduction of gravity irrigation some of these tanks will be good paddy growing fields.

Principal Crops Grown:—The principal crops are paddy, pulses such Mung, Black gram, Kulthi, Oilseeds, including Mustard, Castor etc., Fibre crop, such as Jute, Hemp, Sugarcane, Vegetables, Wheat and Betel leaves are also grown. Out of total C.C.A. 96% however is under paddy.

The area under Rabi is naturally small as there is no irrigation facility, but it is significant that 10831 acres grow pulses, 4130 acres oil-seeds, 7000 acres jute, 750 acres sugarcane, 50 acres tobacco, 239 acres betel leaves.

Thus all types of crops are grown in the area though Rabi is limited by availability of water.

Health and Climate:—The area is highly malarious and people are all emaciated. The climate is moist in monsoon and mild in summer. The nearness to sea makes the summer and winter less severe.

The maximum day temperature is about 105°F in summer and the minimum night temperature is about 60°F. During summer a mild breeze blows throughout the day.

Birgobindpur Weir site from the Right Bank (looking upstream)

Communication :—The area is well served by all-weather roads. The roads on Canals and Distributaries will open up further communication. Railways cross at the Lover Irrigation boundary. Ramchandrapur Canal will run close to the Jajpur-Ranchi Road. Bhadrak-Anandpur Road via. Bonth is also a black topped road cutting across the Anandpur Canal Ayacut.

Population (1951 Census) : —The average density of population in Left Flow Canal area is 450 per sq. mile and in Ramchandrapur Canal area the density works out to 350 per sq. mile. The area is thickly populated and the increase over 1941 census has been about 7% on the average i.e. 0.7% per annum.

Suitability of Soil in C.C.A for Irrigation:—Soil survey for the C.C.A. has been conducted by the Hirakud Research Station and the results are encouraging. The entire area is under paddy cultivation for centuries and limited Rabi cultivation by tank irrigation is also practised. All these years no adverse effects have been noticed.

Crop Season and Crop Pattern:—The two principal crop seasons are Khariff and Rabi. The crop pattern proposed for Khariff is 90% paddy and 10% sugarcane. For Rabi 30% paddy 15% cash rabi and 5% light rabi has been proposed. Rabi paddy is not practicable on account of non-availability of water but the people in the irrigated area are intelligent and hardworking farmers and with the present high price of paddy the Rabi paddy cultivation will prove attractive. No difficulty is anticipated in either light Rabi cultivation or Khariff paddy. Sugarcane development no doubt would depend on the facility to sell sugarcane to a factory. Such a factory if established near Akhuapada will provide easy transport facility in the River and encourage cultivation of sugarcane.

Area Proposed to be Irrigated:—70% of gross commanded area under Left Bank Canal has been taken as C.C.A. Under the Right Bank Canal C.C. area has been taken as 60% as the ground is somewhat cut up and there are rocky patches.

For the left flow canal an intensity of 85% has been adopted in Salandi Report.

Duties and Water Requirements:

The water requirements of canals have been worked out in detail month by month for the crop pattern adopted. The total requirement for paddy is assumed as 60″ and 50% of monthly rainfall has been assumed as useful rainfall for arriving at the net water requirement. A minimum duty of 60 has been assumed for sugarcane. Duty assumed for light Rabi and Cash Rabi is 200.

Water Logging and Provision for Drainage : —At present the only water logged area with high

Balijori Weir site—view of Left Bank

sub-soil water table is the small patch of about 5000 acres at the head of Anandpur Canal.

Only in drought years people reap the crop otherwise in good rainfall years on Khariff crop is possible and vegetables are grown from December to April. It is proposed to excavate drainage channels in the area. The main canal in this reach will be lined.

The rest of the area is free from water logging. No doubt some rise in water table is anticipated and so drainage cuts have to be provided in minor valleys. The drainage of Major Valleys is good.

Manure Problem:—Manure problem is serious in the Ayacut as there are no forests and cow dung is used for burning. The only solution is use for artificial fertilisers and green manuring.

Special effort is necessary to educate the people in maintaining the soil fertility. Intensive extension work will have to be done and it is expected that National Extension Service and special demonstration farms established by the project will do this. A special provision of Rs. 10 lakhs is made in 'O' Miscellaneous for this work.

Malaria:—The malaria problem is there even now and with introduction of irrigation the problem will be acute.

To minimise the effect of canals, purposely, the intensity has been taken on the lower side and irrigation too close to villages will be avoided. During Construction drainage of borrow pits will be provided.

In addition to all this the normal spraying of insecticides which is being done under N.M.C.P. units should be able to keep the meance under check.

BARRAGE AT BIRGOBINDPUR

Two sites AB and CD were investigated in detail.

Site CD: a dolerite dyke crosses the river at this site and rock is visible in the bed. It was expected that fresh rock will be available at high elevations. The barrage is to be designed for 30′ head and one on rock foundation would have been cheaper. Actual drilling revealed that rock is 60′ below pond level and 30′ below bed level. Open excavation would be difficult and a design on permeable foundations would need sheet piling and it is not possible to drive sheet piles at this site. The site was considered unsuitable and site AB was investigated.

Site AB: Here drilling upto 40′ below bed was done and no rock was met with. This site was finally selected as it is possible to drive sheet piles and provide effective cut off.

This site is located about 1000′ upstream of village Birgobindpur, situated on Ranchi-Jajpur Road. The site is 4 miles upstream of Anandpur head-quarters of Keonjhar District.

REQUIRED POND LEVEL

Left flow canal Ayacut can be commanded with a FSL of +140 at the head. As Rabi irrigation is to be extended to Salandi system at a future date, it is necessary that the offtake level for left flow canal should be +150.

Right flow canal Ayacut could be commanded with a FSL of +220. It is now proposed to irrigate 73000 acres with FSL of +150. The balance of land can be commanded from a High Level Canal from the forebay of the Kadobari Power House when this is taken up in Stage II or lift irrigation can be introduced by lifting from the pond above barrage. Total land above +150 contour is hardly 30000 acres and this can be taken up in Stage II.

Hence a level of +150 is adopted for commanding the Ayacut. The pond level is proposed at +150.5 to give a working head of .5 for the head regulators.

DESIGN OF THE BARRAGE

(a) *Maximum flood & method of disposal:*

The proposed barrage is designed for passing 5,00,000 Cusecs with 3′ Affux. The sill level is kept at +130.5. The HFL at the site is +164 and the barrage will pass the maximum flood with upstream level of +167. Total water-way provided is 14 spans of 60′. Coefficient of discharge adopted is 3.4. Velocity of approach has been neglected.

The overall width between Abutment faces is 931′, and the river width is also 930′.

(b) *Upstream & downstream floors:*

The floors are tested for uplift and piping and calculated.

The depth of sheet pile is 2′ below the scour depth. Scour depth is calculated by the formula

$$\text{Scour depth} = 1.25 \times .9 \times \left(\frac{Q^2}{F}\right)^{\frac{1}{3}}$$

Where Q = discharge per ft.
F = Silt factor (Lacey) = 1 (assumed).

(c) *Dissipation of energy:*

Friction blocks are proposed to kill the turbulence after jump formation over the sloping apron.

(d) *Principal Levels & particulars:*

1.	Bed level at site ...	+126.00 (average)
2.	Lowest Level ...	+123.70
3.	Lowest level anticipated due to retrogression	+120.5
4.	Sill level ...	+130.5
5.	Pond level ...	+150.5
6.	Top of shutter ...	+150.5
7.	No of vents of 60′ span	14
8.	Size of gate ...	60 × 20′ in two tiers.
9.	Bottom of downstream pile	+84.5
10.	Maximum expected scour	+86.5
11.	MFL upstream ...	+167.00
12.	MFL. downstream	+164.00
13.	AFFLUX ...	3′.00
14.	Thickness of pier ...	7′-6″
15.	Top of gearing platform	+183

(e) *Piers & Abutments:*

Piers have been tested for thrust. Tension will not develop in the masonry. Pier width is 7′-6″. Necessary stream lining will be done to reduce end contractions. The pressure on the pavement will be 2 tons/sq. ft. and at the foundation the pressure will be 1 ton per sq. ft. The sand encased between piles will take this pressure. Abutments are founded on wells.

(f) *Road-way over barrage:*

At present there is no bridge within 40 miles of the barrage site. It is proposed to provide a bridge over the barrage with 12′ road width.

Estimate

The estimated cost is Rs. 107.0 lacs. Necessary Buildings have been provided. A provision of Rs. 5,00,000 has been made for dewatering and river diversion.

Gates and sheet piles are estimated at Rs. 200/- and Rs. 20/- per sft. All other items are estimated on analysed rates.

LEFT FLOW CANAL (ANANDPUR CANAL)

This canal named as Anandpur Canal will irrigate 1,05,000 acres in Khariff season and 63,000 acres in Rabi season in the District of Keonjhar and Balasore. The proposed area is a vast sheet of level paddy land fully under Khariff cultivation. The area is thickly populated by hard working Kisans who even from now have started looking hopefully to that bright day when water will irrigate their crops and relieve them from the vagaries of monsoon. The important places in the Ayacut are Bonth, Baudpur, Chhenapadi and Bhandari-Pokhari.

Survey conducted so far and proposed :—Detailed survey of the Ayacut is not done as yet and it is proposed to get 4″ = 1 mile maps prepared with 5′ contours and spot levels to locate distributaries, Minors and Water courses and design the channels. The only survey done at present is a series of Cross levels on the proposed alignment at 1000′ centres and locating the alignment on the maps and preparing L. Section. The Main Canal and Branch alignment however will not alter materialy nor the canal capacity in different reaches.

Alignment:—The canal will throughout be a contour canal running in easy country with filling and cutting limited to 30′. The alignment runs parallel to the river at a distance of about 2 miles upto village Chhenapadi where at RD 59 of Main Canal, the Akhuapada Branch takes off. The Canal upto this point will run at the toe of a hill range and naturally it will have to cross as many as 9 Nalas. From R.D. 59 to Tail

at R.D. 84 the Canal will take a turn towards North-east. The entire alignment in this reach runs in easy country through thin Reserve Forest and crosses only small drains.

Design of Canal:—The canal has been designed with Lacey's silt factor of 0.8. The following statement gives dimensions reach-wise:

Reach	Discharge in cusscs	Bed width	F.S.D.	Slope	Velocity
RD 0—59	1230	80′	6.00	.093/1000	2. 4 ft./Sec.
RD 59—70	600	58′	5.10	.104/1000	2.18 ft./Sec.
RD 70—84	380	43′	4.3	.112/1000	1.98 ft./Sec.

Standards for fillings and cuttings:

For fillings, top width of bank will be 25′ on inspection side and 10′ on the other side with 1:1½′ side slopes. Outer slope will be 1:4 with 2′ cover over hydraulic gradient and free board is 3′. For cutting, a slope of 1:1 with a 3′ wide berm at 8′ from bed is proposed.

Masonry Structures:—Designs of Masonry structures have not been prepared but on the basis of line plans the costs have been estimated based on existing rates at which similar structures in Hirakud Project have been executed.

Branch Canal:—There will be one Branch off-taking at R.D. of Main Canal. The length of the Branch will be 25,000′ and will carry 630 Cusecs from head to Tail. As the ground rapidly falls a fall of 18′ has been proposed at R.D. 1000′ and a further fall of 12′ at R.D. 7000′ where a Fall-cum-Road Bridge has been proposed on the crossing of the Canal and Anandpur-Bhadrak Road. The canal bed width will be 58′, and F.S.D. 5.1′. The canal dimensions will be same as for Main Canal except that the free board will be 2′.

Regulators:—There will be 5 Head Regulators including one at the Tail and two Cross Regulators one at the Head of Akhuapada Branch and the other at R.D. 70.

Escapes:—Two Escapes, one at R.D. 37500 and the other at R.D. 74 have been proposed.

Cross Drainages:—Out of a total 10 cross drainage works, the Canal will be taken in Aqueducts over two drains and in the rest, undertunnels will carry the drain below canal. The biggest Aqueduct will be at R.D. 37500 where the canal will cross a Nala with a catchment area of 40 sq. miles. All other Aqueducts and under-tunnels have to cross small drainages. The location of Drainage crossing is given in L. Section.

Bridges:—There will be nine bridges for a length of 84000′ of the canal. The bridge positions have been so adjusted that no bridge will be more than a mile from any point in the Canal. All the bridges are proposed to be 12′ wide except one at R.D. 7000 of Branch Canal which will be 24′ wide.

Buildings:—Necessary buildings to accommodate a Sub-Division during construction have been proposed at Chhenapadi, Bonth and Kendupada. Permanent Sub-Division will be located at Bonth and at all other places inspection Bungalows and Supervisor's quarters will be used by the Sub-Divisional Officer during construction and will ultimately become Sectional Head Quarters.

RIGHT FLOW CANAL (RAMCHANDRAPUR CANAL)

Alignment:—The Right Bank Canal will run within ½ mile of River upto Ghasipur, where the canal will cross the Jajpur-Keonjhar Road. From the Road crossing it will go upto village Rudranarayanpur and the alignment here has been set out with a view to cross Kusai River by an Aqueduct. From Rudranarayanpur upto Ramchandrapur the Canal will be taken in a detour to avoid deep cutting in laterite. The canal will tail off at R.D. 93 from where the distributaries will take off. Upto Kusai the Canal will go somewhat in cutting and after Kusai the alignment runs in balanced cut.

Survey:—Similar survey has been conducted for this canal as for Left Flow Canal.

Canal Dimensions:

R.D.	Discharge	Bedwith	F.S.D.	Slope	Velocity
0—28	900	75′	5.4	0.11/1000	2.25
28—60	810	62′	5.3	0.11/1000	2.25
60—76	720	55′	5.0	0.16/1000	2.4
76—93	655	55′	4.8	0.16/1000	2.4

Canal Standards:—Standard adopted is same as for Left Flow Canal.

Masonry Structures:—Masonry structures have not been designed but on the basis of line plans and comparison with similar structures in Hirakud Project the costing has been done.

Regulators:—There will be 10 Head Regulators and 2 Cross Regulators. For each Major Disttributary Cross Regulator has been proposed.

Cross Drainages:—There will be altogether 15 cross Drainages in this canal out of which 9 will be under-tunnels and 4 Aqueducts and 2 Super-passages. All the crossings are small except one over Kusai which will be a major Aqueduct.

Kusai Aqueduct:—The catchment area of the stream is 296 sq. miles and the maximum flood discharge with 1040 as value of 'c' in Dicken's formula, comes to 74,220 Cusecs. At present there is a Road Bridge at this site with 13 spans of 50′. For this Aqueduct, 14 spans of 50′ are proposed.

The canal will be flumed and as more head room

is available it is proposed to flume vertically as well as horizontally.

The foundations of the existing bridge are on wells in the River bed and open foundations on sides.

For this Aqueduct similar foundations can be adopted. It is not necessary to provide Road Bridge on this Aqueduct as the existing Bridge is quite near.

Bridges:—There will be 11 bridges on this canal. The Canal will be about 18 miles long.

4 are State Highway Bridges and the rest village Road Bridges. 2 of the Cross Regulators have been proposed to be used as Bridges in the combined structure.

Escapes:

An Escape for full discharge of 900 Cusecs has been proposed upstream of Kuasi Aqueduct at R.D. 36. Another Escape has been proposed at R.D. 78 for 900 Cusecs capacity.

ESTIMATES UNIT 2—CANAL SYSTEM

A—Preliminary

A provision of Rs. 4.18 lacs under this head covers the cost of further surveys for final location and preparation of 4" to 1 mile map of the Ayacut by Survey of India and site survey for Major works.

B—Land

This covers the cost of land required for Main Canals and Branches and Colony sites. A provision of Rs. 11.73 lacs under this head has been made. Land has been valued at Rs. 800/- per acre.

C—Head Works

The cost of the Barrage at Birgobindpur estimated at Rs. 107 lakhs has been included in this Sub-head.

D—Regulators

The cost of all Head Regulators of Channels ex-Main canal and Branch have been included under this. Total provision is Rs. 88,500/-.

E—Falls and Weirs

Provision of Rs. 2,01,100 made under this sub-head covers the cost of 2 cross regulators each on the left and right main canal and 2 falls on the Akhuapada branch on the left side flow canal.

F—Cross Drainage

A provision of Rs. 53.17 lacs under this head covers the cost of one major Aqueduct at Rs. 7.5 lacs and the rest is for minor under-tunnels and Aqueducts.

G—Bridges

A provision of Rs. 4,30,000 under this head covers the cost of all D.R. Bridges and Village Road Bridges.

H—Escapes

A provision of Rs. 1,40,000 has been provided for Escapes in both the Canals.

K—Buildings

A sum of Rs. 7,94,000 has been provided for Buildings for one Division.

L—Earth Work

A provision of Rs. 86.61 lacs under this head covers the cost of excavation in all types of soil including all leads etc. and the cost of lining.

A sum of Rs. 40,000 has been provided for Service and Boundary Roads.

M—Plantation

A sum of Rs. 6,000 has been provided for plantation in Colonies.

O—Miscellaneous

A sum of Rs. 17.34 lacs under this covers the cost of Vehicles, Dispensary, Supply of Power and Water, Conservancy arrangements etc. A provision of Rs. 10 lacs out of Rs. 17,34 is for 4 Demonstration Farms in the Ayacut.

P—Maintenance

Provision @ 1% on I-Works except B-Land has been made.

Q—Special T. & P.

Rs. 1,20,000 has been provided.

Distributaries and Minors

A flat rate of Rs. 33/- per acre of C.C.A. to cover all the costs including cost of land has been made for distributaries off-taking from Left and Right Flow Canal.

Field Channels

A Plus and Minus provision @ Rs. 20/- per acre has been made and the cost including interest and establishment is recoverable from irrigation.

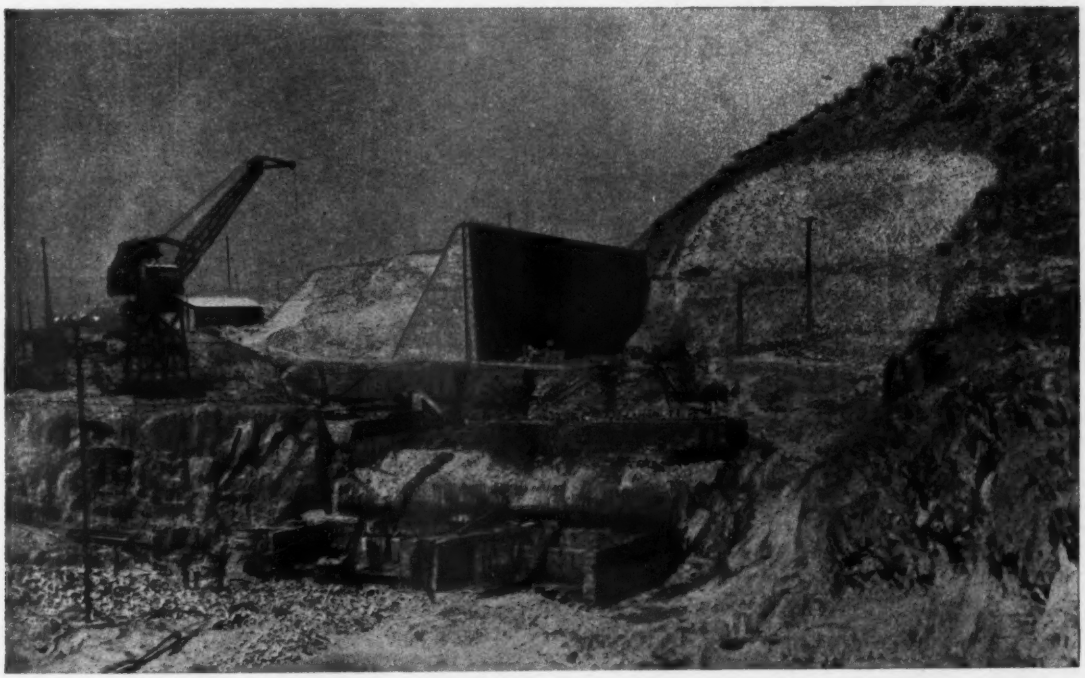
The Chiplima Power Scheme

by M. N. VENKATESAN

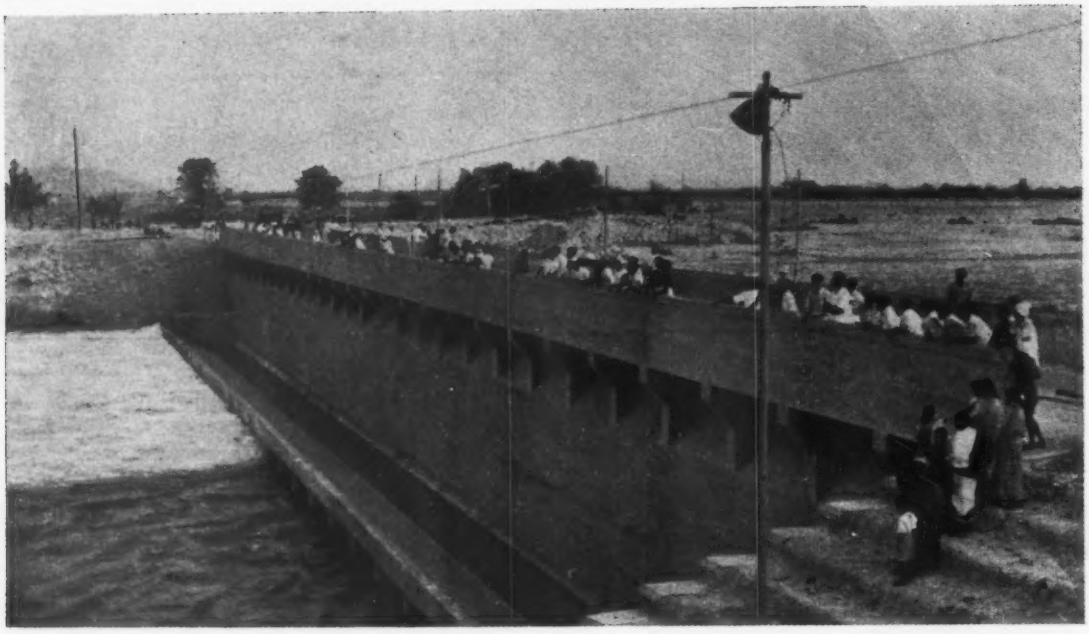
THE Hirakud Dam Project as proposed in 1947 consisted of a Main Dam across the Mahanadi River, about nine miles uptream from Sambalpur (Orissa) with gravity and lift canals for irrigation taking off from the reservoir on either side and a subsidiary dam at Chiplima about 18 miles down the river from the Main Dam. In addition to irrigation and power generation, the Project was also expected to serve for flood control and navigation. The Main Dam and Dykes inclusive of Power House was completed in 1956 with some modification to the original proposals and the power plants were commissioned by end of 1956. This comprised essentially the Stage I of the works of the Hirakud Dam Project.

Stage II of the works comprises construction of a 16 mile Power Channel to convey the Tail Race water of Power House No. I to the Second Power House at Chiplima and the installation of three Generating Units of 24000 kW. Besides two 37500 kW sets will be installed in Power House I. In this paper it is proposed to deal with the civil works involved in the construction of the Chiplima Scheme.

There have been several proposals for the development of Power at Chiplima. The proposal finally taken up for execution in 1948 was that made by the Advisory Committee consisting of Dr. J. L. Savage, Shri M. Narasimhaya and Shri S. A. Gadkary. In this the Power Channel was to take off from a point lower down from above a diversion weir across the right arm of the river and flow in contour ending in a subsidiary reservoir formed by a masonry dam at Chiplima flanked by an earthen bund in continuation of it. The work was started according to this in 1949 with a slight modification. However, the work was stopped in December 1951 as priority had to be given to the construction of the Main Dam. These proposals were re-examined in 1954 by Shri M. S. Thirumale Iyenger, Chief Engineer, Hirakud Dam Project and he recommended that the most economical way of developing power at Chiplima was to take a power canal from the Main Power House tail race in contour but at the end, instead of dropping it into the valley to form a subsidiary reservoir, as per original proposals, to take it along the hill slope and drop the water through penstocks into the Power House located at the same place as before. It was pointed out that in view of the storage facilities already existing



View showing the Hill Channel, right Transition Wall, Power Dam and Power House



Syphon Spillway at work—Downstream View

in the Main Dam a run-of the-river station would serve the purpose eminently. The omission of the subsidiary masonry dam and four and half a mile length of Earth Dam and the substitution of the Hill Channel instead will, it was shown, not only reduce the overall cost of the Scheme but minimise and subsequently reduce the maintenance cost. The omission of the storage reservoir will result in an immediate saving of the cost in that the lands that were to be submerged will no longer be required and the area acquired may be surrendered or sold. The Scheme as modified by Shri M. S. Thirumale Iyenger was approved and construction work started by the end of 1956.

Fig. 1 shows the general lay out of the Chiplima Power Scheme under execution. The water from the Tail Race of Power House No. I is taken through a channel across Hirakud Colony to drop into a balancing reservoir extending from RD-21085 to RD-30106. The second stage of the Power Channel takes off from the Head Regulator at RD-30106 at the end of balancing reservoir No. I and flows in contour almost parallel to the river for a distance of nearly 9 miles, when it enter into the Hill Channel. Enroute there are a number of ponds which help in augmenting the supplies and help substantially the reduction of the loss of head taking place owing to the flow of the water through the channel. The last mile and a half of the canal is a contour canal on the Hill slope ending up with an effective fall at the Power House Site of as much as 77′. The storage at the Forebay is not appreciable and the water cascades down the hill channel through the penstocks into the Units in the Power House and then through the Tail Channel to the Mahanadi River.

POWER CHANNEL FROM P.H. I TO THE BALANCING RESERVOIR

The Power Channel upto the balancing reservior has to take the discharge through the four existing Units i.e. two Units of 24000 k.W. and two of 37500 k.W. and the anticipated discharge from the other Units of 37500 k.W. to be installed at a later date. The normal maximum discharge is likely to be 18000 cusecs. However the discharge from the Main Power House will fluctuate considerably as the fluctuations in the load systems will have to be largely accommodated by the Main Power House. In view of this fluctuating discharge and the geology of the strata through which the canal has to pass, a fully lined canal has been constructed. The canal lined with concrete has a bed width of 170 ft. with a side slope of 1:1 and a bed slope of 1 in 10000. The ultimate maximum discharge of 25000 cusecs is designed to flow uniformly at 21 ft. depth with a free board of of 2 ft.

The total excavation in the first reach upto the balancing reservoir works out to 11 crores Cft. (4.1 M.C. Yds.) The maximum depth of cutting is nearly 53′ and the maximum height of back in the filling reaches 30′. The work of excavation was carried out by both manual labour and by machinery. Table I below gives the quantity of work carried out under each head:

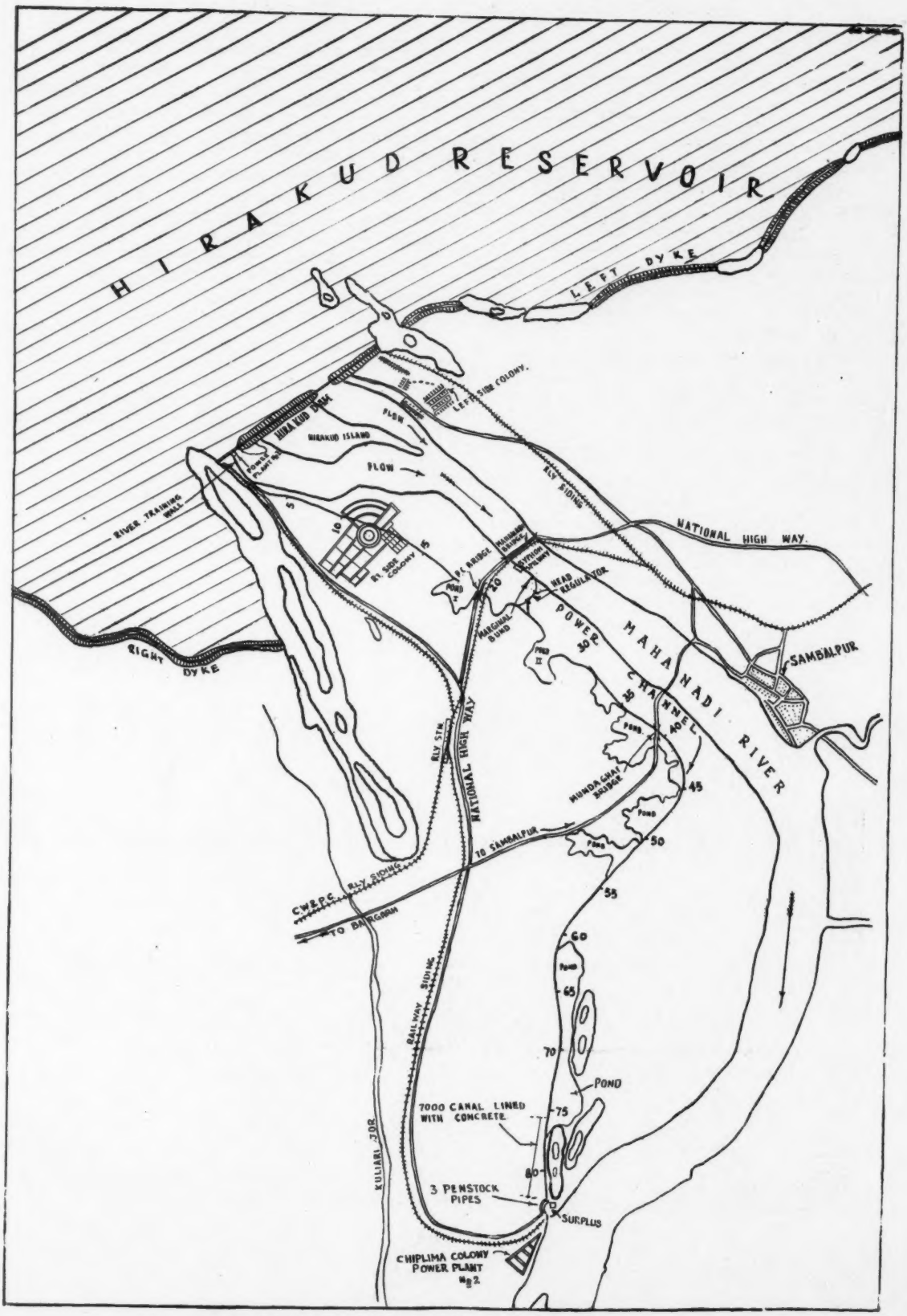


Fig. 1. Chiplima Power House: General Layout Plan

TABLE I

(Table Showing the Details of Excavation)

	Crore Cft.	*M.C. Yds.*
Total Excavation	11.0	4.1
Excavation by Machinery	8.8	3.3
Excavation by Manual Labour	2.2	0.8

The first 3000′ of the Channel runs in original river bed and has an entirely sandy strata underneath. The slopes and bed of the lining in the above reach has been completed with concrete with a mesh reinforcement consisting of ¼″ bars at intervals in both directions. This mesh was available from the Disposals readymade and was rolled in position prior to the concreting.

The lining in the other reaches has been carried out by 4″ thick concrete in situ or laid as slabs both in the bed and the side slopes. The cost of such lining has worked out to Rs. 13.5 lacs per mile.

THE BALANCING RESERVOIR I

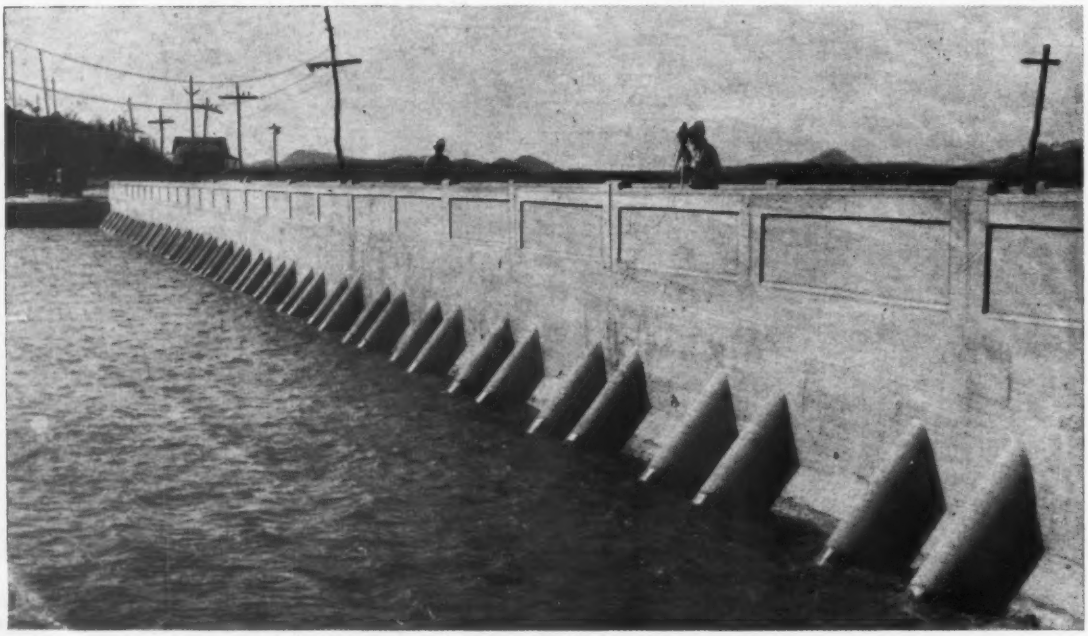
The Power Channel forms into a pond between RD 21085 and 30106 which constitutes a sort of balancing reservoir. The pond acts as a temporary storage and helps to release through the Head Regulator a constant discharge of 13000 cusecs into the second reach of the Power Channel. This reservoir has been formed by forming an Earthen Bund nearly 8000 ft. long, almost along the bank of Mahanadi, at a level much higher than the maximum level of flow expected in the river. This bund is nearly 70′ high in the deepest section and has a volume of nearly 80 lac Cft. The construction of this bund was carried out almost entirely by machinery.

A saddle type of Syphon of length 320′ has been provided in the bund for letting out surplus water if any into the Mahanadi river. The advantage of this type of spillway is that it is automatic and requires a very low lead for priming. Normally all fluctuations in the discharge from the Power House I will be absorbed in the balancing reservoir. This will ensure that there is no wastage of water. This spillway is however designed to provide an outlet for the worst condition of intense rain over the catchment of the pond (i.e. nearly 11 sq. miles) coupled with the contingency of the regulator being out of commission.

The Saddle Syphon as constructed consists of 27 vents of 10′ × 3′ and two sluices 3′ × 5′ which can be operated manually. The total discharge of the spillway is thus 20000 cusecs. The sluices have been provided to supply water periodically to Sambalpur Town during the dry months when there is likely to be no release from the Dam into the Mahanadi River. The maximum discharge of the sluices viz. 800 cusecs will not affect in any way power production at Chiplima as the intention is to open them periodically for flushing the river channel along side Sambalpur Town.

Fig. 2 shows a section of the Syphon Spillway showing the details of the Crest, Ogee, the priming and depriming pipes. The cost of this spillway per cusec works out to Rs. 450/-.

The Regulator at Pond I consists of 6 vents



Syphon Spillway—Upstream View

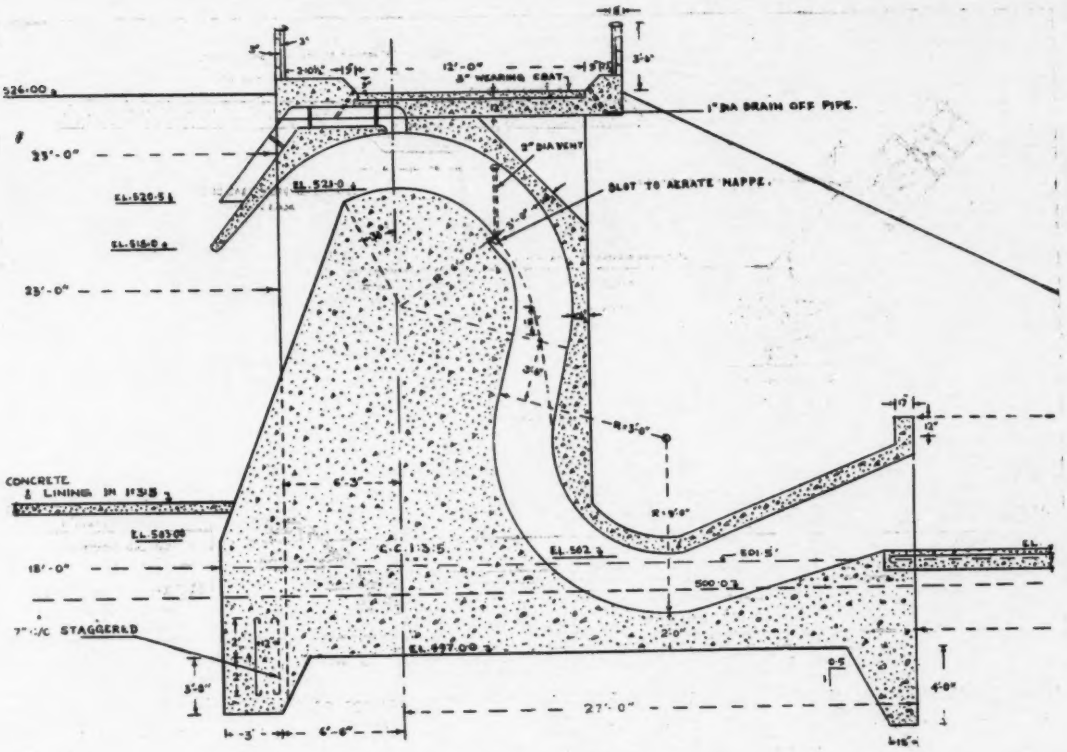


Fig. 2. Section through Siphon Spillway

25′ × 10′ and allows a steady supply of 13000 cusecs into the II Reach of the Power Channel. Six Roller Gates 25′ × 10′ manufactured in the Hirakud Workshops will be operated by Electric Control from the Main Power House to regulate the flow in the Power Channel to suit the needs at Chiplima Power House.

Thus the Pond No. I with the surplus escape and the Regulator will serve the purpose of balancing the variable supply received from Power House I and send a constant supply of 13000 cusecs to Power House II.

THE POWER CHANNEL RD-30106 TO RD-76106

The Power Channel RD-30106 to RD-76106 in the unlined sections is 274′ wide and in the lined sections is 172′. The full supply depth of the canal is maintained a constant at 13′ and in this reach a bed fall of 1 in 10000 has been adopted. The flumed sections with the reduced width have been adopted wherever it was felt that the cutting costs are likely to be considerable.

The geology of the alignment of the Power Channel reveals veins of hard granite rock running across the Channel at intervals or as out crops in the bed. Other than these areas which are in cutting the balance of the channels is in embnkment, the only bank provided being on the river side of the channel thus intercepting the flow of the respective catchments. The Power Channel thus consists of a series of ponds which as explained already help in stabilising the flow, and augmenting the power produced by minimising the loss of head due to flow in the Channel.

The total quantity of earth work works to 9.5 crores Cft. (3.6 M.C. Yds.). The entire work except in the cutting reaches is pitched. A filter and rock toe in the rear to take care of seepage has been provided in all sections where the height of the bank is over 10′.

The lining of the Power Channel in the flumed sections consists of 3″ thick concrete slabs laid in situ in panels 30′ × 20′ over a well compacted Sand cushion. Construction joints packed with bitumen have been provided. The side slopes are built up of 15″ thick pucca stone pitching in cement mortar 1 : 5. The stone for both pitching and lining is invariably obtained from the excavation of the Power Channel. Fig. 3 shows a section of the lining together with the details of the construction joints and side slopes. The cost of this lining works out to Rs. 9 lacs per mile length of Canal for a width of 172′.

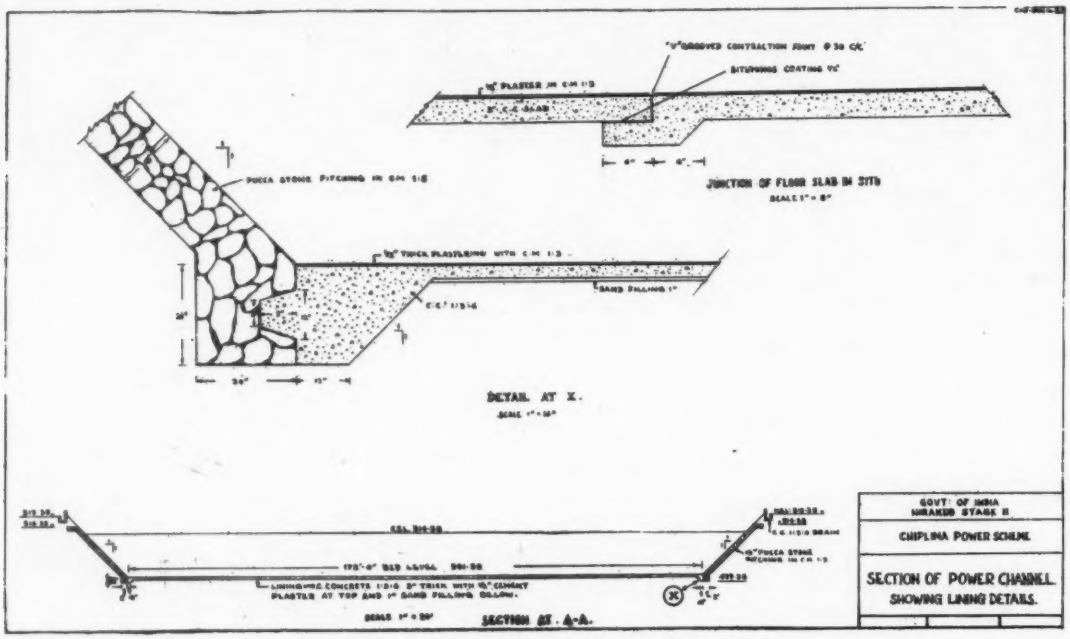


Fig. 3. Section of Power Channel Showing Living details

THE HILL SECTION RD-76106 TO RD-83468

From RD-76106 to the channel runs along the toe of the Lambai Dungri hills and subsequently runs as a contour canal on the hill slopes. The width of the canal in this section is reduced to 126′ in order to minimise excavation costs and the average velocity in the canal with bed fall of 1 in 5000 is likely to be 7′ per second. The canal in this reach is therefore completely lined with 3″ thick concrete laid in situ in the bed and a 15″ thick pucca stone masonry wall in the side slopes. Beyond RD-78106, the contour canal enters higher up the mountain slopes. As considerable quantity of suitable earth from the excavation might not be available for forming the bank of the hill channel and as an appreciable quantity of rock was likely to be available from the hill excavation, the channel bank has been designed as a rock fill section with an earth coating on the canal side.

Fig. 4 shows a section of the hill channel as constructed. The advantages of this section are:—

(a) Maximum utilisation of the rock excavated from the hill slopes.

(b) Minimum of quantity of earth to be hauled for the borrow areas as almost all the earth for the bank has to be hauled from borrow areas outside.

(c) Afford greatest stability against sliding.

(d) Provide free drainage to water that might percolate through the bank and for subsoil water. The latter is bound to be appreciable especially in the rainy season in the valley regions.

(e) Maintenance cost will be lowest.

The slope in the hill side of the canal is being dressed to suit the type of soil available at the site and its ability to stand under saturation. A network of catch water drains is being provided over the slope line at the top of the hill side to tap the surface flow on the slope of the mountain and lead it on into the canal through intermediate drains.

The hill channel and its tail end discharges into the Forebay of Power House II.

THE FOREBAY, POWER DAM & POWER HOUSE

The Forebay is a very limited area enclosed between the hill, the power dam, the transition wall on the right of the spill-way on the left. The capacity of the Forebay is negligible. However, in run-of the-river stations like this with the main storage reservoir close by there is no need for a Forebay of appreciable capacity. Any sudden fluctuations in the level of the Forebay owing to shut down of a unit is taken care of partly by the spillway at the Power House end and partly by a change in the hydraulic gradient of the hill channel upto the pond at the entry into the hill channel.

The hill at the end of the hill channel has been dressed into a series of steps onto which the initial flow of water cascades to reach the level of the Forebay.

In order to prevent any slip or slide of the hill section at the end into the Forebay, a series of holes were

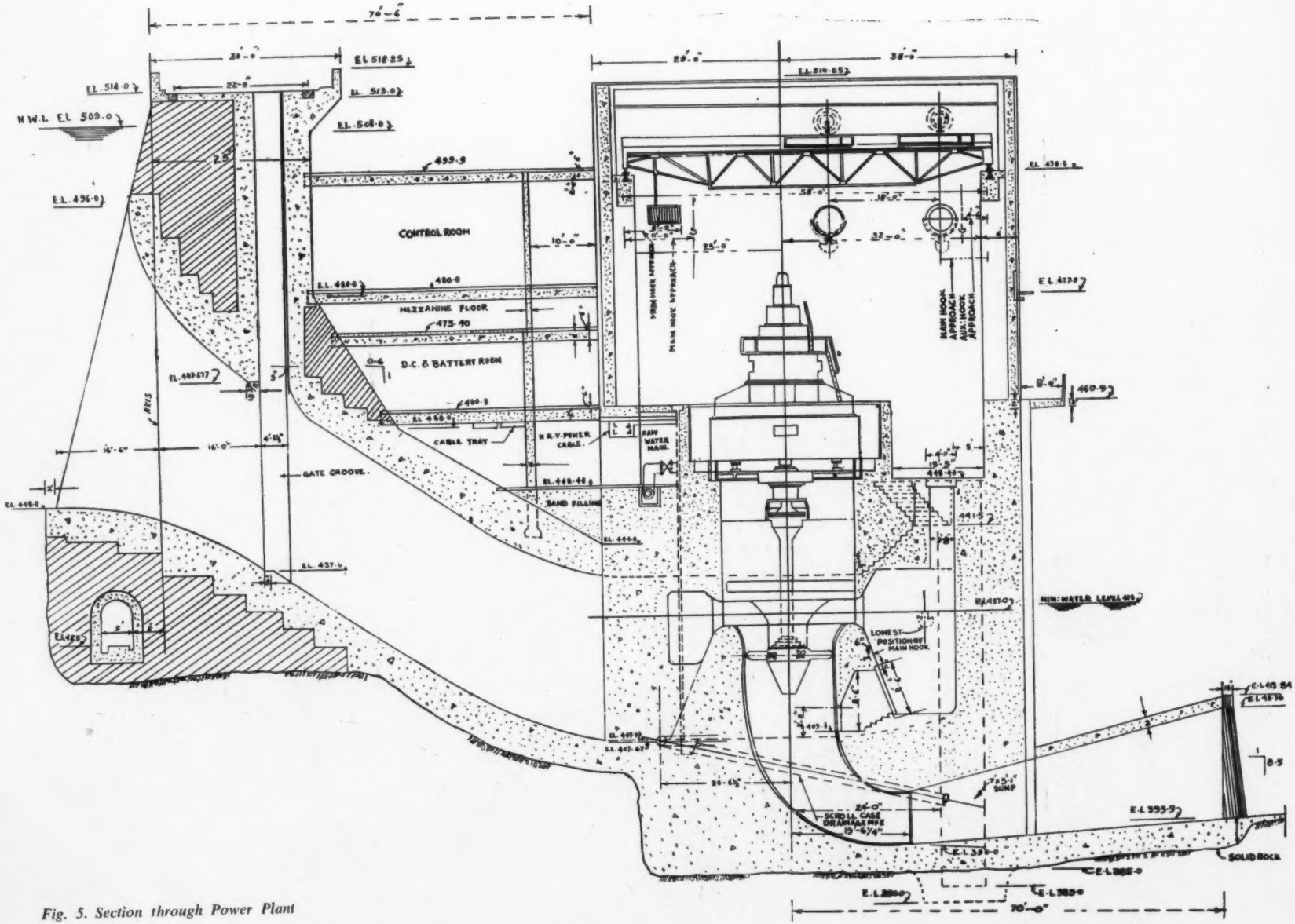


Fig. 5. Section through Power Plant

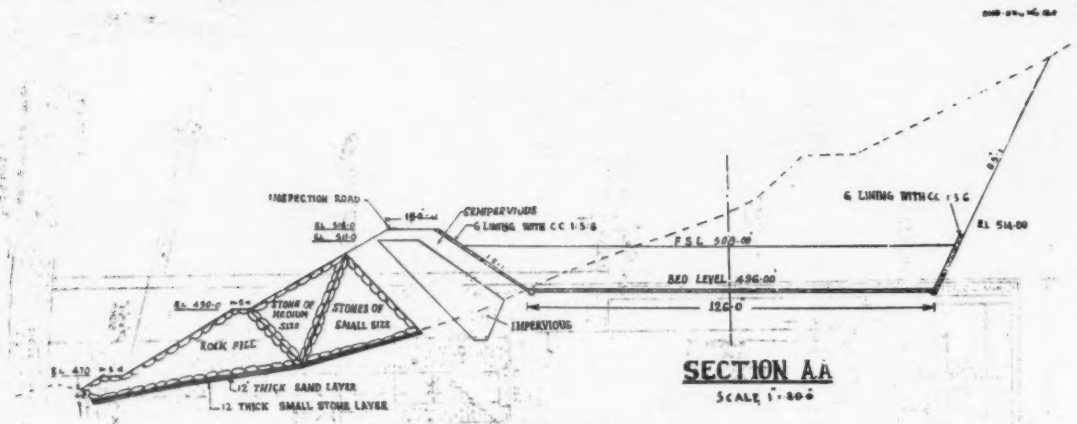


Fig. 4. Section of Hill Channel

drilled to examine the type and compactness of the strata. The result of the drilling and grouting to refusal indicated that the strata of rock at the tail end consisting of hard schists was sufficiently compact and was not likely either to slide or to soften under saturation. It has however been decided to grout the entire slope in order to offer a smooth flow to the water and to prevent erosion especially during the initial filling of the Forebay.

Fig. 5 shows a section through the Power Dam and Power Plant. The Power Dam has an upstream face slopping 1 : 4 from the level of the Forebay. The trash racks are located right on the upstream face and consist of gratings slide down into position along the sliping face of the Dam.

With a view to effect economy in the construction of Chiplima Power House and also to speed up the space it is proposed to adopt concrete intake and scroll case for the units to be installed at Chiplima. This practice is normally adopted in many continental installations such as:—

1. Verbois Power Plant in Switzerland
2. Andre Blondel Power Plant in France.

There seems to be no objection to this practice in low head plants (Head less than 90-100') where the velocities developed in the intake of scroll case are within the permissible limits of concrete. The maximum velocities developed in the Scheme:

at the Trash Racks	3.5 ft. per second
at the Penstock Gate	5.3 ft. per second
and in the Scroll Case	9.0 ft. per second

The normal velocities are expected to be lower still. It is however needless to emphasise that the concrete has to be of the best quality and has to be placed with extreme care and precision.

The water passing out through the Draft Tube is led into Mahanadi River through the Tail Race Channel.

DESIGNS

The Designs for the entire scheme were all made at the Design Section of the Hirakud Dam Project. Model experiments on the Saddle Syphon Spillway and tail race were conducted at Hirakud in rear of Gap II of the Main Dam.

PROGRESS OF WORKS

All the civil works in the Power Channel inclusive of lining have been completed upto the balancing reservoir. In addition all the structures namely the Syphon Spillway, the Head Regulator, the bridges across the Power Channel have also been completed. The excavation of Power & Hill Channel upto the Power House II is almost complete and lining work is in progress. At the Power House Site the work on the Right Transition Wall is over and work is in full swing in the Power Dam, Power House and Spillway. The Draft Tube Liners manufactured in Hirakud Workshops have been assembled and the work on the Scroll Case is being taken up. It is expected that the bulk of the civil works will be completed by December 1959. The orders for the generating sets have been placed already and it is expected that the first two units will start functioning by December 1960.

Technical Notes & News

SUBJECTS FOR THE C.I.B. CONGRESS IN ROTTERDAM

At the general C.I.B. Congress to be held in Rotterdam from 21st to 26th September 1959 under the Honorary Presidency of the Minister of Housing and Building in The Netherlands, eight subjects will be put up for discussion, which may be considered of very topical interest for the development of the building industry. The subjects will be presented in 44 reports, the texts of which—in English or in French, as desired—will be sent to the participants beforehand; if possible a Russian version will also be prepared.

The reports will be drawn up by 54 experts from many countries. The subjects and the main rapporteurs are as follows:

SUBJECT 1: *Sociological and functional aspects of housing design.*

P. Chombart de Lauwe, France; Mrs. J. Meihuizen-Ter Braake. The Netherlands, C. Crappe, Belgium and two Danish experts.

SUBJECT 2: *Design and calculation of constructions: safety coefficients.*

Prof. E. Torroja, Spain; Prof. Dr. A. A. Gvozdev, U.S.S.R. and five Russian experts.

SUBJECT 3: *Introduction to the standardisation of dimensioning on the building site, tolerances and dimension control.*

Prof. G. Ciribini, Italy; Dr. W. Triebel, German Federal Republic; J. Noiré, France and Prof. S. Janicki, Poland.

SUBJECT 4: *Research problems concerning large concrete elements in housing.*

Prof. Dr. G. F. Kutznetsov, U.S.S.R., Dr. M. Jacobsson, Sweden; G. Bonnome, France and six Russian specialists.

SUBJECT 5: *Mass housing in rapidly developing tropical and subtropical areas.*

G. A. Atkinson, United Kingdom; G. A. Doxiades, Greece; Prof. K. Hadinoto, Indonesia; N. Stutterheim and Dr. G. Caledrwood, Union of South Africa; Lt. Gen. Sir H. Williams, India; G. Blachere, France and Dr. O. H. Koenigsberger, United Kingdom.

SUBJECT 6: *Flat roofs.*

Dr. T. W. Parker, United Kingdom; T. Isaksen, Norway; R. Hanson, Sweden and Dr. F. G. Thomas, United Kingdom.

SUBJECT 7: *Fundamental aspects of transmission of knowledge.*

L. M. Giertz, architect, Sweden; J. van Ettinger and K. L. de Vries. The Netherlands; D. Bullivant, United Kingdom; D. Fink, Denmark; M. Molè, Yugoslavia and O. Stach, Czechoslovakia.

SUBJECT 8: *Heat insulation and moisture effects.*

Prof. Dr. H. Reiher, German Federal Republic; A. Tveit, Norway, Prof. Dr. E. F. M. van der Held, The Netherlands; Dr. Poul Marke, Denmark and M. Croiset, France.

PIPE LINE TRANSPORTATION OF COAL

A very unique system has been adopted in the USA for transportation of coal to a large power supply system from the remote coalfields by pumping pulverised coal and water mixture through a pipe line. The products received at the power station are dewatered, dried and used in the boilers. This arrangement has been made between the Pittsburgh Consolidated Coal Co., and the Cleveland Electric Illuminating Co. The main sections are the preparation plant, pipe line and pumping stations, and dewatering and drying terminal. The distance is about 110 miles and there are three pumping stations 30 miles apart. The power plant is of 66000 KW and consumes ½ million tons of coal per year.

The coal used consists of the fines from the cleansing plant and water is taken from a small lake. The main equipments are crushers, screens, storage tanks, drag tank slurry mixing equipment and the pumping stations. The preparation plant was designed for 300 tons/hr and the pipe line for 150 tons/hr. Two pumps of 450 HP each are installed at each of the three stations. The rate of pumping is 530 gallons per minute of the slurry by each pump (contains 306 gallons water and the rest coal). The discharge is at 1000 p.s.i.g. pressure. A surge tank is also provided. The pipe line is 10¾" outside diameter and has welded joints, burried 4 or 5 ft. in the ground at a max inclination of 10 degrees. Velocity of the slurry is 4 to 5 ft./second, and the time required for the slurry to reach the receiving end is about 30 hours. Pipe is enamel painted, covered with glass cloth and is cathodically protected. The slurry is neutralised by caustic to give a min. ph of 6½. An inhibitor and nitrogen is used to arrest the action of oxygen.

Dewatering is done by Dorr thickners, the sludge is then passed through vacuum filters, (which dries the sludge containing 42% water 58% coal). The coal coke has 20% water and is dried further by flash driers. After further drying the coal goes to the bins of the power station. About 1250000 tons of coal will

be transported per year which accounts for 80% of coal used in the power station.

The total cost of the project was $12.5 million of which 2½ million is for the dewatering and drying terminal. The use factor is 90% and the saving is about $3.30 per ton of coal compared with the other methods of transportation.

(Dr.) B. K. R. Prasad.

FIRST 200 MW TURBO ALTERNATOR FOR BRITAIN

The first 200,000 kW, 3,000 r.p.m. "English Electric" reheat steam turbine for the British Central Electricity Generating Board has now successfully undergone Works tests preparatory to being installed in High Marnham Power Station, U.K.

High Marnham Power Station is situated in an agricultural belt in the East Midlands on the West bank of the river Trent. It is within easy access of the East Midlands coalfields and close to the main railway line linking Chesterfield and Mansfield with Lincoln. This 1000 MW station, when completed, will contain five 200,000 kW "English Electric" turbo-alternator sets and will be the largest not only in Britain, but also in Europe. "English Electric" are also supplying five 415V switch and control gear units to High Marnham. Delivery of these units has already begun and will continue in phase with the commissioning of the main turbo-alternator sets.

The new turbine is the largest ever to leave the Rugby Works of The English Electric Company Limited. It is also the first tandem 200,000 kW. steam turbine to be manufactured in Britain. The turbine is typical of the most advanced designs now in course of manufacture at the Rugby Works of The English Electric Company Limited, the largest turbines on order (the largest turbines yet to be built in Europe) being the two 275,000 kW sets for the Blyth 'B' Power Station of the C.E.G.B.

At High Marnham the five turbo-alternator units are arranged in line along the station at 120 feet centres. The total weight of one turbo-alternator unit is 1,450 tons, the maximum lift being that of the alternator stator at 168 tons approximately.

With a running speed of 3,000 r.p.m., the 200,000 kW steam turbine is of the horizontal three-cylinder design having a double casing impulse type high-pressure cylinder. Steam enters the turbine stop valve at 2,350 p.s.i.g., 1,050 deg. Fah.—the highest steam conditions so far attained in any British power station. The steam from the high-pressure turbine exhaust is taken to the reheater and then returned to the intermediate-pressure cylinder at 475 p.s.i.g. and 1,000 deg. Fah.

The intermediate-pressure cylinder is combined with one section of the three-flow low-pressure cylinder and has impulse stages up to the point of exhaust to the low-pressure stages.

Approximately one-third of the steam remaining after bleeding passes through the combined low-pressure portion, and the remaining two thirds is led through two overhead interconnecting pipes to the double-flow, low-pressure cylinder. The three-flow low-pressure cylinder exhausts to a single-shell condenser, the vacuum at the most economical and continuous maximum rating being 28.7 in Hg. (Bar. 30 in.) when using cooling water at 60 deg. F.

The condensing plant includes a single-shell condenser, two full-duty extraction pumps, three 50 per cent duty rotary Leblanc type main air pumps and two quick starting exhausters.

There is a six-stage feed water system giving a maximum temperature of 460 deg. F. at continuous maximum rating. Feed water deaeration is supplied with provision for off-load deaeration.

The alternator is of the latest hydrogen cooled design employing direct cooling of the stator and rotor conductors at a rated gas pressure of 30 p.s.i.g. The hydrogen coolers are arranged longitudinally in the upper part of the stator frame and circulation of the hydrogen through the machine and coolers by means of an axial flow blower. Generation is at 16,500 volts with rated phase current of 7,780 A. at 0.9 power factor.

The exciters comprise a main and pilot unit arranged back to back on the same shaft and driven through gearing from the tail end of the alternator. They are totally enclosed and ventilated on the closed circuit principle, the air being circulated through the machines and coolers by means of a direct coupled fan. The maximum output of the main exciter is 3,000 A. at a rated voltage of 520 volts, the speed of the exciters being 750 r.p.m.

The successful running of the first "English Electric" 200,000 kW, 3,000 r.p.m. tandem reheat steam turbine marks another step forward in the field of generation of electrical energy. Modern steam conditions have necessitated departure from conventional designs and while externally the multi-cylinder unit conforms more or less to conventional ideas there are notable differences dictated by the use of the extra high steam conditions and reheating of the steam.

In the development and manufacture of the High Marnham machine many new problems have had to be overcome. The English Electric Company, however, has always realised the value of a sound research and development programme and was there-

fore able to surmount the difficulties inherent in the new situation. The Company's comprehensive facilities include research and development laboratories employing the most up to date techniques ranging from creep laboratories to digital computers. All phases of development and investigation are covered to ensure reliability in the finished product. With the extra high pressures now obtaining it will be appreciated that reliability in construction and in operation becomes of paramount importance.

'COMPETITION FOR DESIGNS FOR RURAL HOUSES'

With the object of obtaining the best designs for rural houses, estimated to cost not more than Rs. 1,-000/-, Rs. 1,500/-, and Rs. 2,500/-, each exclusive of the cost of land, in each of the three regions—hot-arid, hot-humid and hilly areas (in all nine categories of competition), the National Buildings Organisation, Ministry of Works, Housing and Supply, Government of India, are holding a rural house designs competition. The last date for the submission of entries is 31st August, 1959. First and second prizes have been offered in each of the nine categories of the competition. The first prize will be a medal of value Rs. 500/- and the second prize a medal of value Rs. 300/-. A Committee of Assessors consisting of a nominee each of the Government of India, the Indian Institute of Architects and the Institution of Engineers (India) will adjudge the competition.

Copies of the regulations and entry forms for the competition can be obtained on request from the Director, National Buildings Organisation, 11-A, Janpath, New Delhi, or the Indian Institute of Architects, Bombay, or the Instituion of Engineers (India), Calcutta.

PASSED THE TEST

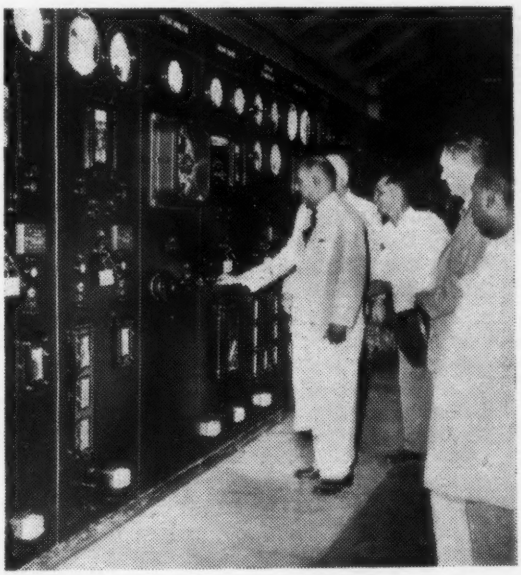
During last summer, the Port of London Authority were dredging in the Victoria Docks, London, a job which had not been done for many years. Among the debris pulled up was a two-wheel trailer which had been blown into the dock during an air-raid in 1940.

The trailer itself was in very bad condition, but the extraordinary thing about it was that the Firestone tyres and tubes with which it was equipped were still inflated at their normal pressure—eighteen years under water and the tubes were still holding all their air!

The gash in the sidewell of the tyre in the picture was made by one of the teeth of the dredger when the trailer was lifted up from the botton of the dock.

A NEW 20,000 K.W. SET COMMISSIONED

Sir Biren Mookherjee formally commissioned in March a new 20,000 kW. steam turbo generator set at

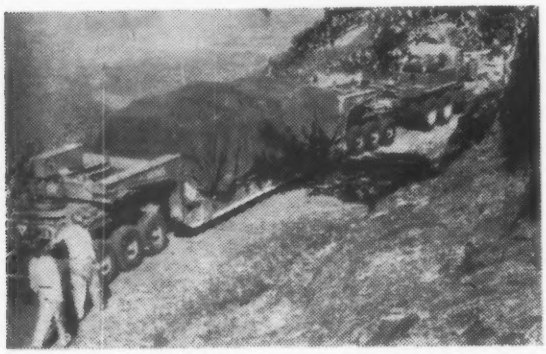


Burnpur Works of the Indian Iron & Steel Co. Ltd., to cope with the mounting power requirements of the Works which is raising its production from approximately half million to one million tons of ingot steel per annum. The new unit raises the installed capacity of the power plant from 40,000kW. to 60,000 kW.

It was initially planned that D.V.C. would supply the entire power requirements of the Burnpur Works, but when it became evident that DVC would not be in a position to supply in time the power requirements of the extended Works, it was decided to install this new set.

GIANT TRAILER FOR KOYNA

Sensational was the successful test run of the giant 57 foot long, 60-ton low-bed trailer designed and



manufactured by Cranes (Dereham) Ltd, over the Khandala Ghat, and the Koyna-Pophali Ghat sections witnessed by the Koyna Project engineers. The Koyna Project authorities have now solved one of their major problems of transporting the heavy transformers and power plants to the site at Pophali by road. The successful run of the Cranes trailer all the way from Bombay to Pophali via Khandala, Lonavla, Poona and Karad, has revolutionised the very ideas of road transportation. In fact, the Koyna authorities can now actively consider revision of the size of the power plants which was originally restricted by the assumed limitations of haulage by road.

The Cranes trailer is not just an improved design. It is a new concept of transportation by road. The custom built trailer is made up of three sections: two 16-wheel identical bogies with one low-bed frame joined to the bogies on either side by swan necks. The swan neck mounting swivels 180° on the turn table of the bogies thus allowing the trailer to turn sharp in narrow roads despite its total length. The bogies incorporate hydraulic suspension and are powered by independent hydraulic pumps. The steering of both the bogies is hydraulically controlled, and with provision for easy change over to manual controls. The bogies are automatically steered when attached to the frame through mechanical steering rods to negotiate any difficult and sharp corners.

The new concept of trailer design is the independent suspension of all the 16 axles. Each set of wheels can be raised or lowered independent of others, as the hydraulic suspension, similar somewhat to those incorporated on aircraft, makes the entire loading and unloading, passing over difficult and uneven grounds, a matter of fingertip ease. The main frame can be lowered or raised by a hydraulic system and the bogies and swan necks can be detached in a matter of minutes. These unique features make this trailer particularly suitable not only for Indian road regulations on permissible axle loads, but also for the Indian road conditions that are so exacting for pneumatic wheeled units.

KANJUR WORKS INAUGURATED

Mr. Y. B. Chavan, Chief Minister of Bombay State inaugurated the Kanjur Works of Crompton Parkinson (Private) Ltd. on 28th February. It will be interesting to remember that this firm commenced manufacturing of ceiling fans at Worli in 1938. Since then it has continued to expand into new directions, manufacturing industrial motors, transformers, motor control gear, FHP motors, switchgear and exhaust fans. The present site was not able to give space for the expanded transformer, switchgear and motor control gear departments. It had, therefore, to be shifted to a new site at Kanjur. The Company takes keen interest in training Indians at all levels in the technical lines and sends out such trainees for advanced training to countries like U.K. The process of Indianisation of the Company is now being speeded up.

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Part II—Thermal and Water Power Engineering from 10-1-60 to 29-2-60."

(Continued from page 32)

NOAPARA DAM

Clubs and Community Centres, Bank, Post & Telegraph Office, Watch & Ward, Security, Market has been made.

Colony Roads, Electrification, Water supply and Sanitary fittings are also included under this head.

M—PLANTATION

Provision under this head is Rs. 2 lacs out of which Rs. 1 lac will be spent on improvement to Dam site after completion and another Rs. 1 lac is meant to be spent over a course of years in Colony Plantation, Gardens, Lawns etc.

O—MISCELLANEOUS

A provision of Rs. 78.25 lacs under this head covers, the cost of Hospital equipment and running and maintenance for 8 years, Anti-Malaria Operations, Running & Maintenance of Field Research Station, Cost of Cameras, Projectors and running expenses for same, purchase and running expenses of Inspection Vehicles, entertainment to Labour and Staff, Publicity, Fire fighting equipment and its running and Security expenses etc.

Provisions for award to workers, Inauguration Ceremony are also included under this head. A special provision of Rs. 15 lacs has been made for Soil Conservation.

R—COMMUNICATIONS

A provision of Rs. 33.50 lacs under this head covers the cost of Low Level Bridge below Dam, new roads of National Highway standard, and necessary facilities at the Rail head at Jajpur Road Station and Badampahar are also included under this.

P—MAINTENANCE

1% on works has been provided.

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OUR CONTRIBUTORS

Mr. M. S. Thirumale Iyengar hardly needs any introduction to our readers. He has been the leading figure in planning and executing the Tungabhadra Dam and subsequently became the Chief Engineer of the Hirakud Dam Project. He was President of the Institution of Engineers (India) and Chairman of the Central Board of Irrigation and Power. His achievement in establishing the 4.5 million pound Testing Station for concrete and masonry at Hirakud is indeed noteworthy. He has represented India in many International Conferences and his contribution to dam construction has been outstanding.

M. S. Thirumale Iyengar

Mr. P. V. A. Narayanamurthy joined the Madras Government Electricity Department as Assistant Engineer, Electrical, in 1935 after serving for about 8 years with Tata Power Co.,International General Electric Co. and Bezwada Municipality. He became Superintending Engineer in 1947 in the Government Electricity Department and in that capacity he was in charge of the differerent Hydro- and Thermal Systems and Technical Branch till 1955, when his services were lent to the Damodar Valley Corporation. He was Deputy Chief Electrical Engineer and later Special Officer in the Damodar Valley Corporation till June 1958, when he joined the Orissa Government as Chief Electrical Engineer.

P. V. A. Narayanamurthy

Mr. N. Dharmarajan, after graduating from the Madras University in Engineering 1922 was engaged in Railway constructions till 1933. In this year he took up a post as a Resident Engineer in a British firm of Transmission Engineers till 1945 when he joined the Government of India as a Project Officer in the C.T.P.B. now merged with C.W.P.C. In the C.W.P.C. he was responsible for the designing of the various substations of the Damodar Valley Corporation. From 1952 he has been with the Hirakud Dam Project as a Superintending Engineer (Electrical) till June 1959. The entire power system was mostly designed, constructed and commissioned under his supervision. For the expeditious way in which he got the Power system through, the President of India decorated him with "Padma Shri".

N. Dharmarajan

Mr. S. C. Tripathy joined the Orissa Public Works Department as Assistant Engineer in 1945 and was deputed subsequently to Hirakud Dam Project where he worked as Sub-Divisional Officer and Executive Engineer till end of 1958. Early this year he was posted to Central Water and Power Commission from where he has now come on deputation to Orissa P.W.D. and is now engaged in Power Resources Survey of Orissa.

S. C. Tripathy

Mr. K. S. S. Murthy has been Executive Engineer in the Hirakud Dam Project, as Technical Assistant to the Chief Engineer for several years, working with

great credit. He is now with the Kosi Dam Project, Bihar.

Mr. M. N. Venkatesan. After graduation with honours from the College of Engineering, Madras in 1944, he was employed in the Public Works Department, Madras, on construction works at Madras and at Mandapam Camp. In 1945. he joined the Central Technical Power Board, Government of India, and worked on the preliminary planning, investigation and design of Damodar Valley Projects.

M. N. Venkatesan

In 1949, he joined the Central Water and Power Commission and was looking after quality control of construction of the Hirakud Dam Project in its early stages. He was sent to U.S.A. on a UNESCO Scholarship for advanced training with the U.S. Bureau of Reclamation and Army Corps of Engineers in Soil Engineering with particular reference to earth dam construction. On his return he joined the Central Water and Power Research Station at Poona and was responsible for carrying out investigations for a number of Projects both for various State Governments and agencies.

He took over as Executive Engineer in charge of the construction of Chiplima Power Scheme in February 1957 after a short stay at the Central Water and Power Commission at New Delhi.

Mr. J. M. Patnaik. After obtaining degrees in Physics and Electrical Engineering from the Madras University in 1942 he took training for a year in the Madras Electricity Department. He worked for 2 years in Tata Iron and Steel Company, then joined the B. T. H. Company and worked in their main works at Rugby and Kearsly power stations of the Lancashire Electric Supply Company, Manchester, from 1946 to 1948. After return from U.K. he worked for 3 years in the Hirakud Dam Project and then joined the Electricity Department of Government of Orissa as Executive Engineer.

J. M. Patnaik

Mr. K. R. Chandrasekharan is Assistant Executive Engineer with the Hirakud Dam Project.

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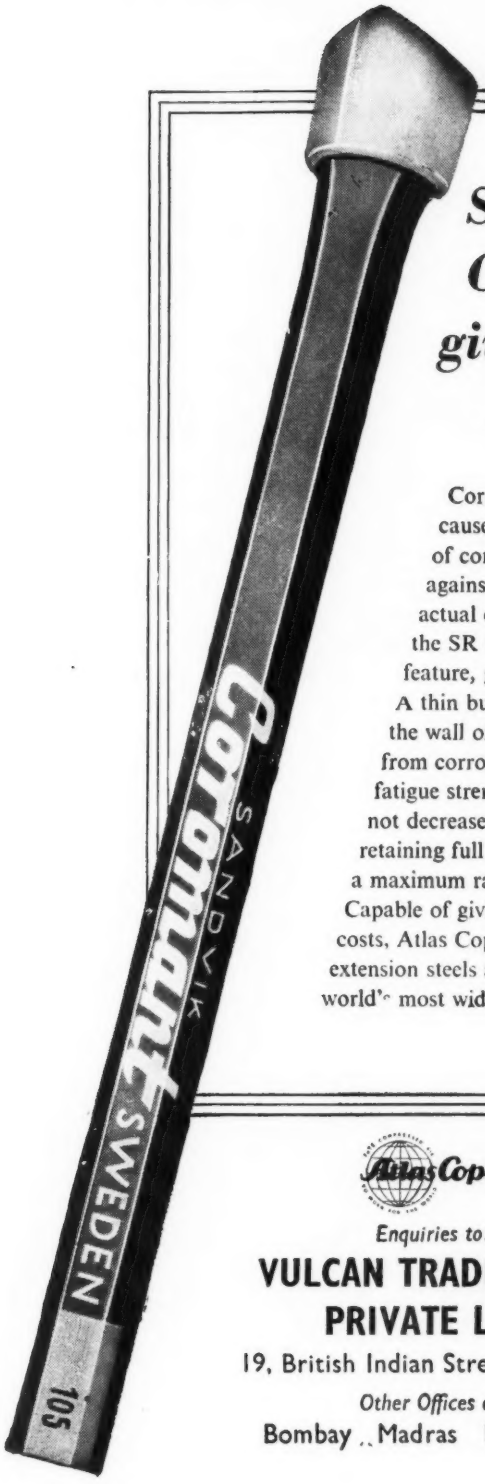

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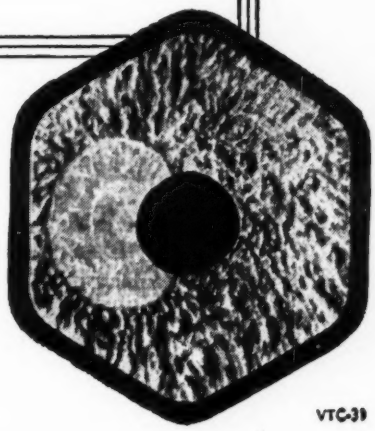

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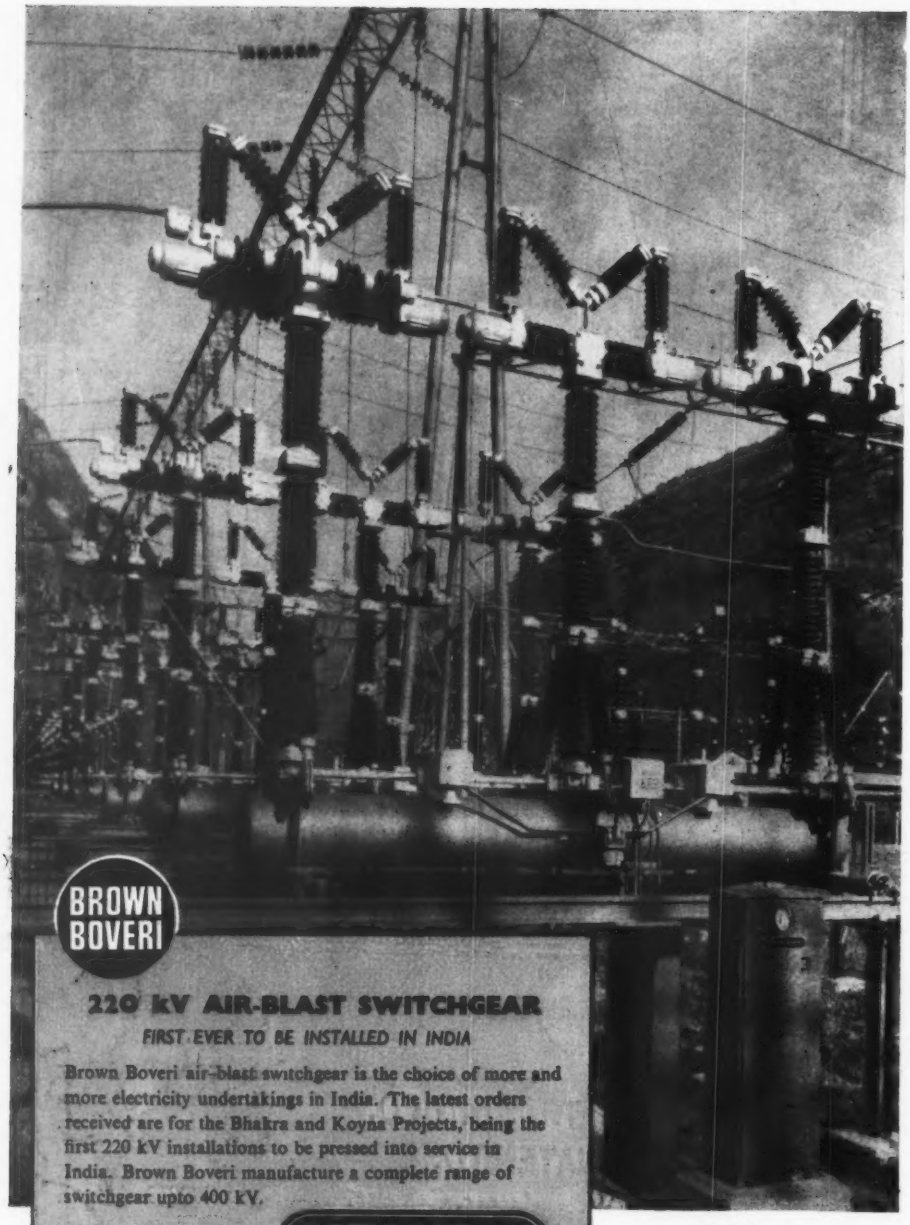

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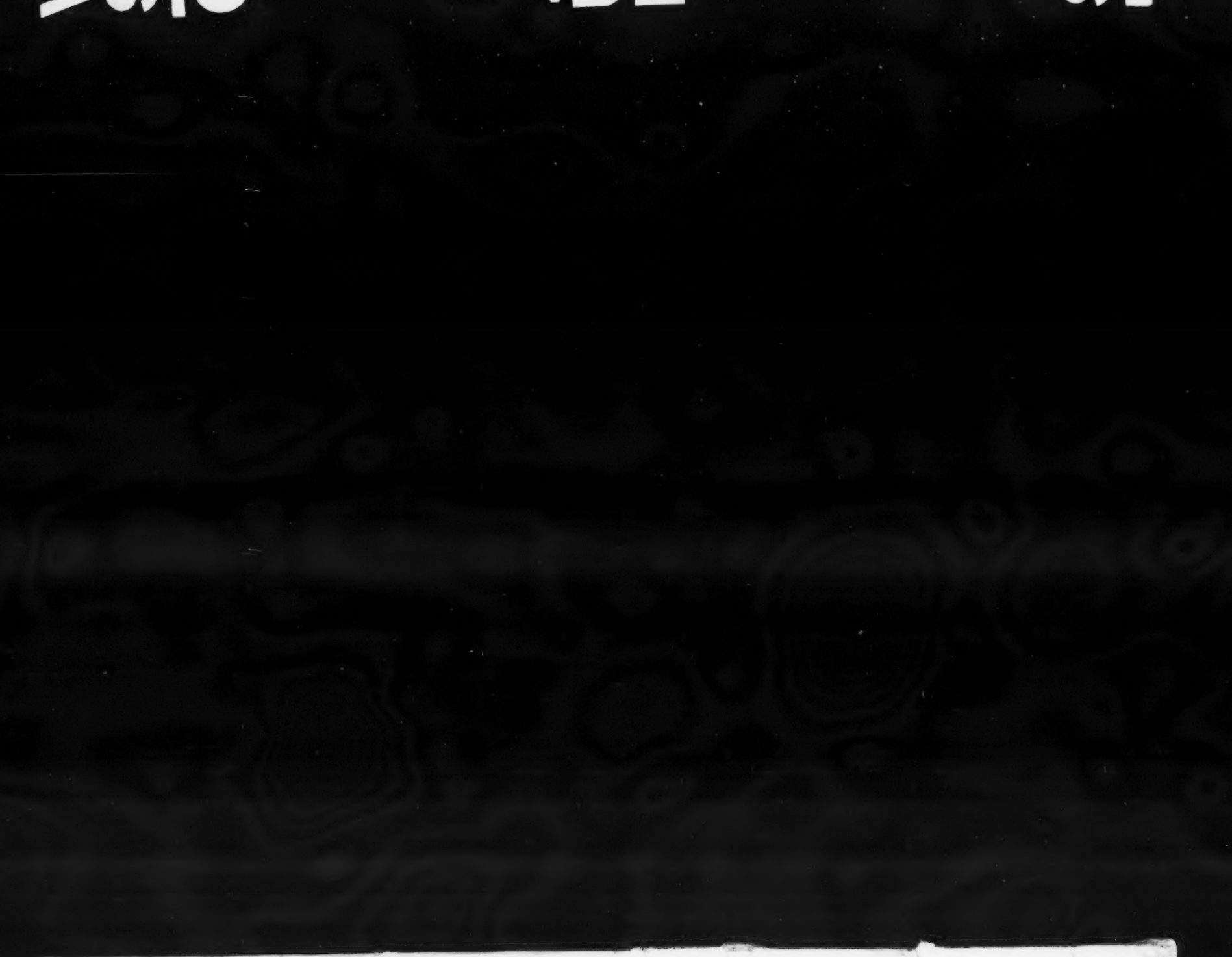
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